MAUU5900

MASTER THESIS

in

Universal Design of ICT

May 2021

An usability and universal design investigation into hamburger menus

Nawaraj Khadka

Department of Computer Science

Faculty of Technology, Art and Design

OSLOMET

Preface

As the world moves ahead into the digital age, different applications across different devices, with variation in designs and ways of interactions are evolving every day. This study is about hidden navigation design patterns in websites, how different navigation designs impact the usability, and how they comply with the principles of universal design. The study has been carried out to fulfill the partial requirements of master's degree in Information Communication Technology, Faculty of Technology, Art, and Design at Oslo Metropolitan University.

The basis for this research came from my passion with design of frontend technologies in websites. As a student of universal design and a developer myself, detailed researching on the impact of hidden navigation designs, and thinking over to possibly develop an optimum solution was an interesting matter for me. Different phases of the study: studying the background, designing the prototype, finding the participants, performing experiment, and analyzing the data, were all a part of a good learning process.

I am obliged to get an opportunity to study and complete my thesis under the umbrella of Department of Computer Science, Oslo Metropolitan University. My sincere gratitude and respect go to thesis supervisor **Dr. Pietro Murano,** for continuous guidance, unwavering support, and supervision on tiniest of the details throughout the whole study. In truth, I would not be able to complete the thesis without his contribution.

I also wish to thank all the participants of the study for their time and cooperation, without whom this thesis would be incomplete. I would like to express my thankfulness all the friends, my parents and colleagues who kept me motivated.

Nawaraj Khadka

Student, Master's Degree Program in Universal Design of ICT

5/13/2021, Oslo, Norway

Abstract

With the implementation of different interface designs in applications across various devices, the concerns related to usability in these designs have also increased. Navigation is an important functionality in websites and the effectiveness of website is impacted by how the navigation is designed. The increase in use of hidden navigation patterns, particularly 'hamburger' menu icon, has raised debates regarding usability of the navigation design and the icon itself. This study seeks to investigate the usability of hamburger menu design pattern in websites, comparing the efficiency and satisfaction level of the design with two other design patterns: hidden navigation design without hamburger icon and tab navigation design. Although few studies are already there which compare the performance of hamburger menu design pattern with other design patterns in mobile applications, not much research has been made to compare the efficiency from the perspective of usability and universal design in websites. This research examines the performance of 45 people across these navigation design patterns through variations in tasks, using hypothetical deductive method. Total time taken, total errors made and opinions of participants regarding the navigation design were collected as a part of experiment. As a quantitative study, the results were analyzed using independent one-way Anova for validity, using SPSS as a tool. The findings indicate that hidden navigation design patterns are less usable, inefficient, and comply less with the principles of universal design as compared to tab navigation design. The inefficiency is more noticeable for complicated tasks. The research also pinpoints that the 'hamburger' icon itself is an understandable metaphor and is usable for experienced users. The outcome of the research can be beneficial for future relevant fields of research, as well as for user interface designers and experts.

Keywords: Hamburger menu, tab menu, universal design, usability of navigation.

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Background

With many people of the world using the internet, the use of various applications across various platforms is also increasing and is expected to increase even more. The websites and applications have also adopted different interface design patterns which can be implemented across all the devices. Navigation plays an important role in any application. It is a system of GUI elements which guide users through web sites, determine the position of where they are, guide them to plan their actions and help to get back if they are not in a proper navigation item(Rosenfeld, 2002). Menus play important role in both computer applications and web sites(Leuthold, 2011). Menus give access to functionality in computer applications whereas in web sites, it gives access to navigation items and functionality(Leuthold, 2011). The navigation system needs to be fast and effective(Leuthold, 2011). Navigation design has also an important impact on overall design structure and plays a significant role in influencing customers who do not like overwhelming screen links, time consuming unnecessary options or clicks(Hasan, 2016).

Icons have been used to represent a concept, objects or even tasks in computer environment(Gittins, 1986). It is crucial that the users of an icon should have the same understanding as the developer of the icon regarding the entity represented by the icon(Frye & Soloway, 1987). Although the transition from text-based to graphic based or icon based approach in computer environment is based on an intuition that 'a picture speaks thousand words', researchers feel that more study is needed to develop standards and guidelines to reduce errors and improve user performance(Kacmar, 1991). Icon based menus are popular and hamburger menu represented by an icon with three bars has become popular navigation method in the design of User Interface in mobile(Pernice & Budiu, 2016). Hidden navigation patterns like hamburger menus is one of the many patterns influenced by mobile first designs(Pernice & Budiu, 2016).

1

'Hamburger' menu is an element on top right (or left) of screen which shows the hidden navigation after user interacts with the element(Garczarek-Bąk, 2016). It has been used widely in desktop and mobile applications, but it is a design pattern inspired by mobile designs(Pernice & Budiu, 2016).It is believed to be introduced in the early 80ies and rise of mobile web and responsive design has increased its popularity(Nesler, 2016). The icon consisting of three vertically aligned bars was first introduced at the Xerox start workstation(Bulboaca, 2019).   Facebook has a role in spreading it after they used it both in their native mobile applications and mobile version of website in 2010(Tsiodoulos, 2016a). Designers got addicted to the hamburger menu due to its convenience and each day millions of mobile and desktops are served with 'hamburger' icon (Pernice & Budiu, 2016). But still several cases have been there about the big companies who first implemented hamburger menus at first but quickly switched to other navigation (Casadei, 2017). Facebook and BBC for instance, used this menu at first who later identified that this type of menu provides lower discoverability and users had problems in locating menu options (Casadei, 2017).

The concept of design for all or universal design is also important aspect to consider while designing any system whether it is physical or computer system (Persson, Åhman, Yngling, & Gulliksen, 2015). It is important that products are designed for all the possible customer base and possibly wide range of people should be able to use them (Persson et al., 2015). In order to achieve this, everything which is designed by people should not be inconvenient for a particular group of people and should encompass evolving diverse human being in the future too(Persson et al., 2015). The problems like lower discoverability and increase in task time could be a problem for those who have cognitive problems and for novice users who are unfamiliar with the icon and the design itself. These problems might bring a question of whether the design of hamburger icon is universal and if wide range of users can use it without any problems. Persson et al. (2015)argues that even specialists can have problems with the design components because of the complexity of design itself.

'Simple and intuitive to use' and 'perceptible information' are two of the seven principles of universal design (Persson et al., 2015). The former explains that any design should be simple and easy to understand regardless of user's prior experience, background, or

language. The latter on the other hand explains that design should communicate all the necessary information to the users in effective way regardless of the sensory abilities of the users. Considering these principles and the conventions which need to be followed for inclusive design, it is doubtful whether the two principles 'simple and intuitive to use' and 'perceptible information' are encompassed by the design of 'hamburger' icon for menu navigation.

This paper investigates into the usability of icon-based hamburger menu and tries to find if it does not follow some of the basic universal design principles, the usability of which is still in question. To answer the issues, three different prototypes with and without hidden navigation design are designed and tested.

1.2 Problem Statement

Menu design plays a vital role in easiness of navigation and its usability. The order in which menu has been presented also has significant impact on the navigation(DeWitt, 2010). Inconsistency in formats, difficulty in navigation and difficult to understand the contents are few of the usability problems which are frequently seen in many commercial websites(Y. Lee & Kozar, 2012).Navigation accessibility problems affect the interaction with mobile devices as well(Casadei, 2017). Menu design and navigation also has many issues regarding the usability. Navigation being one of the main activities which users conduct while they interact with the websites, it has become a challenge to find a compromise between usability and mobility with various mobile and desktop devices(Geven, 2006). With universal usability being a challenge for designers, the accountability of technological variance, user diversity and gaps in user's knowledge is a necessity for designers as well (Shneiderman & Hochheiser, 2001).

Navigation of any web site involves multiple steps. Users must identify the information at first, understand the system of menu, predict the links to follow as well as understand contents after reading them (Yu & Roh, 2002). It involves a series of cognitive processes. Disorientation and cognitive overloads are few navigational issues (Yu & Roh, 2002). Users also need to create a mental navigational map of the links to use navigation properly (Yu & Roh, 2002).

The use of 'hamburger' icon as a representative of the menus and showing the menus after user interacts with it has raised many questions including the issues of usability. With few websites still not implementing hamburger menus and use of an ambiguous icon for hiding the navigation menu, it has raised a question whether the use of such menus can provide consistent and simple navigation for the online users. The use of 'hamburger icon' is a trend in website designs and is popular(Garczarek-Bąk, 2016). Despite its popularity, few studies have mentioned that it is less efficient and is difficult to recognize as a navigation pattern(Abreu, 2019).It is said that using a hidden navigation or using an icon to expand the menu not only hides information initially but also gives users an extra thinking task to locate where the icon is if user needs to navigate and is also ambiguous (Abreu, 2019; "Killing Off the Global Navigation: One Trend to Avoid | Nielsen Norman Group," 2014). It is also unclear whether the icon used is a global icon for menu and navigation("One Hamburger, Hold the Menu | Cooper," 2014).

When navigation design of website is unclear and ambiguous, users might feel disturbed and it could lead to loss of location of site, which in long run might influence users not to return to the website(Hasan, 2016) .A research conducted by perceived irritation in online shopping shows that impact of improper and ambiguous website navigation design on perceived irritation of costumers is significantly high and there is a necessity for online retailers to simplify the navigation design of the websites and allow consumers to navigate the site effortlessly and quickly(Hasan, 2016) .

1.3 Research Objectives and Questions

This study sought to answer questions regarding the usage of hamburger menu not only in mobile applications but also in desktop applications. The previous studies try to answer few major questions which are as follows:
1. Does hidden navigation hinder user performance and gives bad user experience?
2. Is hidden navigation less discoverable?

The previous studies have tried to measure the total time taken for task accomplishment and if the hidden navigation is less discoverable. However, it does not answer if the icon

known as 'hamburger' is a metaphor for menu navigation and users view regarding this. The studies not clearly mention whether the user performance of the menu design with hidden navigation could be improved removing the menu design on the home page only.

Based on the previous research and finding and considering the usability of applications, the following are the research questions:

1. Does hiding information make an interface simpler or makes it even complex, and is the hamburger menu design usable?
2. Is 'hamburger' icon an understandable metaphor icon for menu navigation?
3. Are there any better alternatives to the hamburger metaphor?
4. Is having 'hamburger' menu in web site the best thing or an informative text instead of icon would improve usability?

2. Literature Survey

Much research has been made for menu navigation, usability of computer applications and few on the usability of design patterns in different web, desktop, and mobile applications. One of the prominent functions a website or any application provides is menu navigation. It is a two-stage process which involves finding a website that is related to individual's interest followed by locating information within the website itself(Pilgrim, 2012). The menus within the website or application facilitate the navigation when individual is inside a website and it is a necessity for the menu to be easily visible. It is the first step of website usage followed by the content and other goals(Armando J. Rotondi, 2007).Undoubtedly it is a common feature in desktop application as well as content rich mobile applications. It not only allows the user to navigate, but also provides a structural representation of application. Availability of an excellent navigation feature is extremely crucial for people to achieve their goals with few errors and improve usability(Y. Lee & Kozar, 2012).

Usability is a point of focus and researches have shown that the central theme of usability is to employ a technology to achieve a goal context in relatively easy way(Coursaris & Kim, 2011). Developing a usable website is crucial for online businesses and platforms because online consumers use websites to know how a product, organization or a business is(Y. Lee & Kozar, 2012).It refers to the extent to which specific users can use the website and achieve specified goals in a specific context with efficiency, effectiveness and satisfaction(Agrawal & Venkatesh, 2002). Learnability (how easy it is for users to perform task for the first time with the design), efficiency (how fast a task can be performed by users?), user satisfaction (how pleasing the design is?), memorability (how easily users can reestablish proficiency when users return to a particular website?), errors (how many errors users make and how easy is it to recover those errors?) are among the important considerations of usability(Nielsen, 2012) . If a website lacks characteristics like simplicity and consistency, then there is a chance user might be confused and prefer competing sites instead (Cappel & Huang, 2016). It indicates that to constantly retain users, usability also plays a great role. Usability advocates argue that usability is not given the attention it deserves although

web usability appears to be an important concern now(Cappel & Huang, 2016). The study puts forward opinion about the importance of simplicity and consistency in any application and how to help users achieve their goal without problems. The whole websites impression on user is dependent upon how its navigation is structured because users do not want to be confused when seeing any application for the first time.

Undoubtedly, people prefer efficient applications. Several studies have found that usable navigation is one of the factors which influences website's efficiency(Y. Lee & Kozar, 2012). An extensive study of academic journals, guidelines and web documents conducted by Y.Lee& Kozar(2012) states that navigability, learnability, simplicity, interactivity, readability and consistency are few of the common dimensions of website usability. They conducted an experimental survey with 776 participants taking Amazon's website as the context. It further adds the importance of navigability and shows that it is one of the important constructs of websites usability. The constructs for navigability were multiple ways to access webpage, easiness to locate what users are looking for and multiple pathways to a target webpage. Simplicity and consistency were found to have effect on navigability and it had a direct impact on purchase intention of online costumers(Y. Lee & Kozar, 2012). These constructs clearly indicate the importance of navigability in making any application efficient which supports the research on hidden navigation and its impacts.

One of the reasons why the design of 'hamburger' menu was made and navigation was hidden initially is to make the user interface appealing and simple when a user sees it (Abreu, 2019). Aesthetically pleasing interface undoubtedly is welcomed by most of the users. However, a study puts forward a perspective that no matter how aesthetically pleasing an interface is, if it is not usable then the whole system might not be preferred by users after using them. S.Lee & Koubek (2010) divided usability as a combination of two concepts: pre-usability (perceived usability before using any interface) and user performance(task completion time. The research investigated on the effect of design attributes on user preferences. The context was evaluation of e-commerce web sites and they experimented with nine online books stores to be used by ten participants. The results indicated that the effect of navigation system design was more than the effect of

visual organization, typography, and color. The correlation of navigation system with other design attributes like content organization and visual organization was very high (S. Lee & Koubek, 2010).

Research on menu design have compared different kinds of menus available for navigation and have investigated which type of menu is more usable for any web site or application. The design of navigation structure has direct impact on creating a good or bad user experience (UX) (Murano & Khan, 2015). A research was conducted by P.Murano & Khan (2015) comparing pie menu and linear menu to find out which one is better in terms of user performance and satisfaction. An experiment with 16 participants was conducted and a quantitative and qualitative analysis of the collected results was done. The results indicated that no such significant difference was observed for performance in terms of time and errors quantitatively. But the subjective opinions showed that pie menu was preferred more positively than the linear menu (Murano & Khan, 2015). This research adds knowledge to the book of existing menu types and user preferences.

Likewise, a research conducted by D.P. Murano & Lomas (2015) on whether positioning of menus matter or not using a fictitious online store as context simulating a normal shopping type activity where users look for item to buy through the online store. They tested screen activity of users on four different menu positions: top horizontal, left vertical, right vertical and bottom horizontal. The total number of mouse clicks and errors made were the main aspects of interest. The statistical results indicate that users top horizontal and left vertical menus incurred less errors, fewer mouse clicks and more user satisfaction(D. P. Murano & T. J. Lomas, 2015). Menu positioning on bottom of the page had the worst performance in the research conducted(D. P. Murano & T. J. Lomas, 2015). Although no statistically significant indicators were there to differentiate in terms of task time, the authors suggest that positioning menu vertically on left or horizontally on top would help a web site or application to make it universally designed concerning two universal design principles: "Simple and Intuitive Use" and "Tolerance for Error" (D. P. Murano & T. J. Lomas, 2015).

An earlier study conducted by Burell & Sodan (2006) investigated on style of navigation preferred by users among six different styles of menus available. They explored commonly seen navigation styles grouping them into six categories: Tabbed, Left Navigation Bar, Top Navigation Bar, Combination of Top and Bottom Bar, Combination of Top and left Bar, and Combination of Top and Right Bar. The results showed that Tabbed style of navigation was preferred by the users, which was followed by Top Navigation Bar, Combination of Top and Left Navigation Bar and Left Navigation Bar (Burrell & Sodan, 2006). The bottom and right side were not so popular among the participants (Burrell & Sodan, 2006).

The understanding of where user expects the common web objects like menus (internal links in website), advertisements and external links, and constructing a website by locating these objects in a specific location, is as crucial for designers as crucial it is to follow the existing design patterns and conventions(Bernard, 2001). A study was conducted by Bernard(2001) to find out where users generally expect different components of web page to be. A total of 346 participants were there for the study (Bernard, 2001). The context was a depiction of browser window with eight horizontal and seven vertical grid squares within a window, each card with several components of a webpage represented as a web object (internal and external links, advertisement banners, external web links. Back to home page button, internal search engine). The results show that users (novice and experienced) generally expect the position of menus or internal links within a website to be at the left position (Bernard, 2001). The study does not investigate much into hidden navigation under an icon but somehow puts a perspective of where user expect menu to be, which is left side.

A study conducted by J.Kalbach &Bosenick (2003), however shows that there is not significant difference in the task completion time whether main site navigation menu is placed on left side or right side. The context was a test on relaunched website of Audi (www.audi.com and www.audi.de) . (Kalbach, 2003) further mentions that there is a drawback to right-side justified menu because of the interaction with browsers 'back' button because the function is closer to left side navigation rather than on the right side and having a navigation on the right side obviously will increase the interaction time between the main navigation and back button of browser. The position of menu icon on

the left side opening the whole menu on click event is somehow justifiable in the context of 'hamburger' menus because generally they are placed on the left side.

Menu design has become a crucial issue for human computer interaction and the effect of menu design on searching performance and browsing performance is also significant (Yu & Roh, 2002). Yu & Roh(2002) have investigated on three types of menus :pull down menus (menus appear over objects in interface instead of static menu area), global and local navigation menu (two part navigation links with navigation links of global level at top and links of local level pages on the left side) and simple selection menu design (similar to table of contents in a print book). They found out that the effect of the menu design was not the same on searching and browsing performance and people preferred 'pull down menu' instead of other menus available because it produced a flexible path mechanism. It could also be useful for direct searching tasks (Yu & Roh, 2002). It also has been mentioned that users who require a searching task will look for short paths to locate the target (Yu & Roh, 2002).

However, showing the navigation after a certain event (the way hamburger menu operates) has created debates in the UX Community as well as it hides the navigation(Rand, 2019). Despite the studies and opinions regarding the optimum position of menu, still there might be questions which need to be answered (Murano & Sander, 2016).

It is believed that the design of hamburger menu is inspired from mobile devices. Mobile devices concentrate several functionalities in a single device, which is one of the reasons why they are popular(Damaceno, 2018) . Although significant progress has been made in mobile devices, there are certain boundaries in interface of mobile devices due to characteristics of these devices(Constantinos K. Coursaris, 2011). Content rich applications which have various levels of hierarchy in content face challenges in mobile devices due to limited space of the user interface. Following the rise in the usage of mobile applications and content rich applications, a lot of research have been carried out on appropriate menu system and how the selection could be made more efficient for desktop applications and mobile and comparison between different methods have been done(Zhao, 2004).

Earlier days study about navigation and mobile browsing take us to a study conducted by Kyungdoh Kim(2011) who compared 3D and 2D menus for smartphones. The study results indicated that users preferred the 3D revolving stage menu when the menu had higher breadth while the 2D menu showed better performance in menus with lower memory load and complexity(Kim, 2011).

It is unclear whether the use of hamburger menu and the design is a general convention in user interface design for navigation. However a study has been conducted on how users adapt to new designs and it shows that even though design conventions are not followed by everyone and innovations are added with time on the design, people might get used to with new design by learning by doing(Constantine, Lockwood, & AD, 2002). Constantine et al.(2002) have developed a paradigm known as Anticipatory learning which has four major elements: novelty, anticipation, learning and confirmation. The model proposes that user is rewarded after guessing how an element works if any new element is encountered and when the elements required for anticipatory learning to take place are present, the period of trial-and-error is reduced(Constantine et al., 2002). It might imply that the use of icons to represent web components can be useful provided the condition that icons are perceived as an element for opening menu elements, which might not be the case for different people.

Following a particular design convention for menu is an unquestionable matter for many designers while few also argue that standards and conventions need to be broken if required to improve usability(Santa-Maria, Dyson, & C, 2008). A study was conducted by L. a. D. Santa-Maria, Mary C (2008), to find out whether violations of general visual-conventions in web design has effect on user performance and disorientation over time. Two study groups were tested : one using conventional forum design and the other using less conventional forum design (Santa-Maria et al., 2008). Task completion time, number of navigational corrections and number of wrong answers were recorded. The context was web forum with 12 convention violating page variations and 12 conventional pages. The results showed that although the time taken for task completion is comparatively more for convention violating pages in the beginning, the disorientation and hindered performance is short-lived. Likewise, no significant difference was found in number of right answers between the group (Santa-Maria et al.,

2008). It puts forward a perspective that people learn over time even if novice and convention violating designs are there.

Another research has also shown that users learn where the elements are in the user interface supporting (Constantine et al., 2002) . McCarthy(2004) carried out a study which shows that websites which confirm user's expectation of menu positioning lead to faster search times as compared to those which did not confirm users' expectations.

Some of the navigation features in may introduce accessibility barriers for those who are disabled(Brajnik, 2008).Krug(2014) brings up an important aspect of usability stating that a web page should be self-explanatory, and users should not bother much to think about what it does. Using hidden navigation or using an icon to expand the menu not only hides information initially but also gives users an extra thinking task to locate where the icon is if user needs to navigate. Krug puts forward several common questions (why is it here? Can I click it? Is that a navigation?) which come normally in users mind if one is confused and suggests avoiding such designs which make users think(Krug, 2014). He further argues that users will eventually leave a website if navigation is not simple and users do not find what they need because they are too frustrated to keep on looking specially when website is not familiar(Krug, 2014). A clear and well-designed navigation is undoubtedly one of the opportunities to create a good impression on users.

Garczarek-Bąk(2016) researched and examined on the essential features of a very good business websites and ongoing trends in website design. He further states that the increasing use of hamburger menu is a trend towards simplicity. However, it is hiding the navigation until user needs to interact with it (Garczarek-Bąk, 2016).

(Fichter, 2016)says that the main purpose of the hamburger icon is to open the sliders when users click it. It has been used widely in different mobile and web applications and web designers feel that if users are not aware about it then they will learn about it(Fichter, 2016). The use of icon is supposed to provide "a clean and uncluttered look" in mobile devices and free up some space on the screen(Fichter, 2016).

A qualitative analysis done by Constantinos K. Coursaris(2011) on more than 100 published existing studies shows that efficiency, ease of use and memorability are few of the important measures to evaluate usability of any application. Efficient navigation is

very crucial to make any mobile application usable because navigation is one of the important constructs of usability evaluation (Constantinos K. Coursaris, 2011). The more easier a system is to use, the less resource is consumed, The study puts forward opinion stating that it has become a necessity to consider how a navigation works on mobile devices as much as it is important to design how it works on desktops and laptops (Constantinos K. Coursaris, 2011). It gives practitioners an idea about which mobile usability dimension is important, among which ease of use and memorability are on the top list of factors which cannot be achieved without easy navigation (Constantinos K. Coursaris, 2011).

There have also been researches on feasibility and usefulness of icon-based menu on mobile devices. Schröder & Ziefle(2008) investigated the feasibility and usefulness of icon-based menus in mobile devices for 76 different menu items. They experimented on 56 persons and took the suggestions for pictorial representation for linguistic terms for the menu items. Menus were constructed based on suggestions and a comparison of icon-based menu with text-based menu was done. Effectiveness, Processing time, Item selection time, User acceptance of menu type were among the factors used to measure effectiveness and satisfaction. The results indicate that despite although people are familiar with text based menu, the effectiveness is high for icon based menu as well since 39 out of 40 participants were able to complete the assigned tasks with icon based menus within specified time (Schröder & Ziefle, 2008). Likewise, they also found that the processing time for selection reduced by 75 percent with time using the icon-based menus. It shows that there is a strong relation between type of information and how it is represented (Schröder & Ziefle, 2008). The study puts forward a perspective that icon-based menus can be convenient for people with time due to learning effect but does not explain much about hidden navigation and its effects.

According to Thomas S. Tullis(2005), one of the difficulties users have in website is due to poor navigational structure. A study was conducted by Casadei(2017) while investigating the accessibility issues of user interface (UI) in mobile design patterns in online community. A study of 18 virtual communities in mobile and 127 documents were analyzed to provide recommendations (Vitor Casadei, 2017) . The study mentions that there are basically two design patterns in mobile navigation: Drawer menu (also known

as hamburger) and tab navigation. From 28 sources, the study reports that although the hamburger menu offers the possibility of quite a few navigation options that don't occupy screen space (only when the navigation button is triggered), it obstructs the discoverability of content(Vitor Casadei, 2017). It has also been mentioned that users who use hamburger menu to access applications use less menu options because they either do not recognize the hidden menu under an icon or cannot memorize that the menu exists (Vitor Casadei, 2017). It is also considered as one of the problems which affect the gesture interaction with mobile devices(Vitor Casadei, 2017). Like other studies, it also mentions that due to use of hamburger menus navigation is hidden from the users and users need to have previous knowledge that the menu can be accessed by clicking a button. It has a low information scent, navigation is still obstructed even with a label because users do not have idea about the options available(Vitor Casadei, 2017). Users need to perform extra action to move to the destination targeted and at least two taps (one on the main menu and another one on the target option) is required(Babich, 2019). It might cause an increase in information cost for the users because more time is consumed during the process.

Nesler (2016) argues that although the use of hamburger menu helps to reduce complexity, gives more space to design and uses an icon which is wide spread, it still has some usability issues (Nesler, 2016). A major aspect is hidden information which forces users to think, discover or even memorize the information later. Schade (2015) also supports the use of hamburger menu because it serves as a way of giving navigation information to user only when they need it (Schade, 2015). She puts forward an important aspect stating that "the reason why it is useful can be a reason why it is harmful". According to her, there is a higher information cost for the same navigation if it is hidden behind a hamburger menu or even a Menu label and failure to locate the menu and expose it might cause limited interaction with the website itself(Schade, 2015).

Likewise, lack of a persistent global navigation on desktop has created more issues on desktop due to its use(Schade, 2015). According to Singleton (2015), the critics claim that the use of hamburger menu simply adds an extra step for navigation. He further adds that the icon used is not necessarily universally recognizable and older users

might be confused about its usability(Singleton, 2015). Cooper (2014) points out that users have the tendency to explore the body of a page before they resort into a hamburger menu and make wrong steps during the process. Cognitive load for recall of where the menu is, and frustration due to awkwardness of design when menu structure is complex are few of the disadvantages("One Hamburger, Hold the Menu | Cooper," 2014).

A qualitative study by Cardello & Whitenton (2014) states that websites which have less number of global categories or menus should fit the menus in a horizontal navigation bar and hiding them in a drop-down menu is unnecessary(Cardello & Whitenton, 2014). However, they support the use of mega menus on desktop (large drop-down menus with several links) for large number of menus if headings are clear and menus are well organized. On mobile, however, due to small screen size it is very frustrating to include everything on the menu which is the reason why designers use responsive design hiding the menus at the beginning and showing a button which launches the global navigation menu and this design has also impacted desktop navigation design somehow as many websites have introduced a visible navigation bar which display the menu contents in drop-down(Cardello & Whitenton, 2014). They give example of amazon's website to support that availability of alternative ways of navigation can be useful for users to discover contents within a website even if there are a greater number of menus.

A usability test was conducted by Pernice & Budio(2016) over 179 participants to measure navigation usage, content discoverability, time and task difficulty of three different types of navigation designs. The designs were hidden navigation (main navigation placed under and icon and action required to display it), visible navigation (visible navigation bar and could be seen at simple glance) and combo navigation(some navigation links hidden while others are visible) (Pernice & Budiu, 2016). The participants completed two tasks each on 6 different sites both on desktop and mobile versions. Navigation use, time to navigation, task difficulty, content discoverability and task time were the metrices to measure the effectiveness of the designs. The results revealed that people were significantly more likely to use the navigation when a part of navigation or all of them were visible (Pernice & Budiu, 2016). Only 27 percent

participants used hidden navigation on desktop whereas on mobile 57 percent people used hidden navigation. The reason for this could be relatively small icon on desktop version whereas it is noticeable in mobile devices (Pernice & Budiu, 2016). Hidden navigation had low content discoverability, high task difficulty ratings and more time for task accomplishment. Participants preferred visible navigation and combo navigation (navigation with both visible and non-visible menus) more than invisible navigation. The study mentions that low familiarity, low discoverability of menu icon, extra work for visitors and low familiarity on desktops might be the reason why people preferred visible navigation to hidden navigation(Pernice & Budiu, 2016). Considering the effect on mobile and desktop devices, the study mentions that hidden navigation is more likely to reduce content discoverability on desktop versions compared to the mobile versions.

With few researches still questioning about the usability of icon based 'hamburger' menu and users not adapting with this efficiently, Shneiderman & Hochheiser (2001) have pointed out few challenges of innovation for universal usability which prevail for those who late learners. Technological variety, user diversity and gaps in user knowledges are the common challenges for innovative designs (Shneiderman & Hochheiser, 2001). For those who are first time users, there is necessity to bridge the gap between what users know and what users need to know and designers should be aware about it(Shneiderman & Hochheiser, 2001).

3. Methodology

It is crucial to start with a well-structured research method specially when the topic of research study is new (Lazar, Feng, & Hochheiser, 2017). The field of HCI is multidisciplinary, research methods used in social science as well as engineering and medical science is equally required for these kinds of researches(Lopes, 2016). HCI research should be relevant to design, people or the organization and should also be capable of influencing different processes involved in development and training of interface. A rigorous and appropriate method is only capable of achieving these aspects of HCI research (Lazar et al., 2017).

Qualitative research methodology are better suited for answering the questions like "why" or "how" whereas quantitative methodologies answer the questions of "how many" and "how much" more effectively (Rohrer, 2014). The studies which are qualitative in nature generate data by direct observation. It is rich in details and mostly preferred for subjective studies like social sciences and those studies which focus on meanings and characteristics of different events and are descriptive in nature(Richard, 2013). It is mostly based on smaller target sizes (Lopes, 2016). Focus groups, surveys and interviews are few techniques to obtain answer of what, how and why a problem exists and how to fix them too(Lopes, 2016). However, it misses the attributes like amount or quantity of the subject matter being studied, while having a detailed description of what, how and where of a thing(Berg, Lune, & Lune, 2004).

Quantitative on the other hand make the use of measurements or instruments such as analytical tools to gather the attitudes and behavior in questions indirectly(Rohrer, 2014). It is often about statistically significant sample sizes, designed mainly to answer questions concerning amount, duration or any quantitative factor which gives an answer of how much(Lopes, 2016). The numerical data concerning to a field of study can be obtained through these kind of studies which is popular in HCI researches to some extent(Lopes, 2016). It is easier for a researcher to get a practical outcome using quantitative approach, which can also give a benefit of statistical analysis(Lazar et al., 2017). Likewise, it makes the data collected more reliable giving an opportunity for

anyone to replicate both the test and result, which makes it less open to argument (Elkatawneh, 2016).

Solely focusing on tasks only is not enough to design and implement effective system, which somehow recognizes the importance of qualitative approach in HCI researches(Cairns & Cox, 2008).There is also a growing need on the subjective research to get collective perceptions of various user groups (Adams, Lunt, & Cairns, 2008). Guidelines, heuristics and a variety of techniques could be used to identify potential usability problems with the interface design proposed(Lazar et al., 2017). It is also argued that the HCI researches based on interface designs focus more on the practical outcomes rather than on theoretical aspects (Carroll, 2003). A better and holistic picture of what's going on in the field through manipulation of variables is one of the advantages of quantitative approach (Elkatawneh, 2016). Since this study aims to measure discoverability and efficiency of different navigation designs, quantitative measurement of time taken is an important factor. Considering the advantages of quantitative approach in HCI research along with a possibility of replicating the experiment if required in future, the same approach has been used for this study. Feedback from user is also collected to study the usability and user satisfaction about study.

4. Research Method

Experimental research is a design approach which uses a standardized procedure holding all the conditions constant except the experimental variable (Ross & Morrison, 2004). This standardization ensures high experimental control and has high internal validity as well(Ross & Morrison, 2004). It helps to manipulate the way a research is conducted and allows researchers to find out the actual cause of phenomenon(Lazar et al., 2017). Maximizing the internal validity is very essential for any experimental research and what separates a true experiment from other designs which are less powerful is random assignments of subjects to treatments(Ross & Morrison, 2004). Lazar et al (2017) has also added that randomization of tasks, proper measurements of outcome, a good control over unnecessary variables are some of the attributes of appropriate experimental research. Taking the attributes and practices of experimental research into consideration, following steps were taken in this research to complete the study:

- Identification of the issues
- Study of previous research and development of research questions
- Design of experimental prototypes
- Validation and testing of prototypes for usability and accessibility
- Pilot testing from technical as well as universal design aspect
- Recruitment of participants
- Conduct research experiment and collection of data.

4.1 Research Hypothesis

Hypothesis is a brief statement about the outcome that is expected to occur (Sutton & Staw, 1995). Logical argument about why empirical relationships are expected to occur should not be a part of hypothesis(Sutton & Staw, 1995). It is smaller, narrowed and focused statement which a single experiment can test (Rosnow & Rosenthal, 2008). A researcher's attempt to study the phenomenon and prediction about the variables can be seen on hypothesis typically phrased as "if-then" statements(DeMatteo, Marczyk, & Festinger, 2005).

The hypotheses were devised for this research experiment to find out which navigation design performs well, takes less time to use and is usable. Few hypotheses were related to the discoverability of the navigation menu in all the designs. In addition, few hypotheses were related to the comparison between hidden navigation with hamburger icon and hidden navigation with label "Menu" instead of hamburger icon. Four different hypotheses were designed based on the factors to be measured and total number of tasks be carried out. Each hypothesis has one null hypothesis represented by H0 and one alternative hypothesis represented by H1.

Hypothesis 1

a) H0- There will be no difference in the time required for participants to discover navigation menu for all the designs.
b) H1 -Participants who use menu design with hidden navigation will take more time to discover navigation menu.

Hypothesis 2

a) H0 -There will be no significant difference in the time required for participants to complete the tasks for all the navigation menu designs.
b) H1- Participants who use hidden navigation will take more time to complete the tasks.

Hypothesis 3

a) H0 -There will be no difference in number of errors made by participants for all the menu designs.
b) H1- Participants who use hidden navigation design will make more errors than the ones who use tab navigation with mega menu.

Hypothesis 4

a) H0 -Participants will be satisfied equally for all the menu designs.
b) H1 -Participants who use hidden navigation design with or without hamburger icon will have less user satisfaction as compared to the tab navigation design.

4.2 Research Variables

4.2.1 Independent variables

Independent variable is the factor which is in control of the researcher. It has two levels: present or absent(DeMatteo et al., 2005). The group which is exposed to the independent variable is known as experimental group (DeMatteo et al., 2005). In this study, the independent variables were the three different navigation designs since the prototypes were in control of the researcher. Likewise, the designed tasks for users to perform also were independent variables.

4.2.2 Dependent variables

The dependent variable is simply the measurement of the effects caused by independent variables(DeMatteo et al., 2005). In this study, the performance of the participants while using a menu design and feedback after experiment was conducted were dependent variables. The factors to measure the performance were total time taken to complete the tasks and errors made by the participants while performing the tasks. The total time includes time taken for participants to discover the main navigation menu in each task for a menu design chosen for experiment. Incorrect selection of menus, wrong clicks, incorrect results, and number of unnecessary mouse clicks were considered as errors.

4.3 Research Design

A suitable research design reveals important findings related to the area of study(DeMatteo et al., 2005). Research designs usually fall into one of the three categories: experimental, quasi-experimental and non-experimental (DeMatteo et al., 2005). An experimental design is characterized by randomization. A quasi-experimental design uses multiple groups whereas non-experimental does not have any of these characteristics (DeMatteo et al., 2005). Considering the advantages of true experiment and randomization of tasks, a true-experimental design has been conducted in this study with the following characteristics:

- Four different testable hypotheses are designed.
- Three different types of prototypes are designed.

- Quantitative analysis of dependent variables is done.

- No biasness among the participants is done.

- Quantitative analysis of dependent variables is done.

- Randomization of prototype is done before the participants perform experiment.

4.3.1 Between Groups

A between user design is a design in which participants are exposed to only one experimental design and has shorter sessions (Budiu, 2018). Similar approach was used to check the effects of menu positioning with an experiment designed for 56 participants (P. Murano & T. J. Lomas, 2015). The reason was simply to remove learning effects in the participants(P. Murano & T. J. Lomas, 2015). It has shorter sessions, easier to setup and furthermore limits the learning impact over various conditions(Budiu, 2018). This study also has followed the same between group experiment with three groups of participants performing tasks in three different prototypes without being exposed to other prototypes. The following diagram illustrates the between user groups experiment implemented in this study.

Participant One   **Participant Two**   **Participant Three**

| Website with hamburger icon and hidden navigation | Website with tab navigation | Website without hamburger icon and hidden navigation |
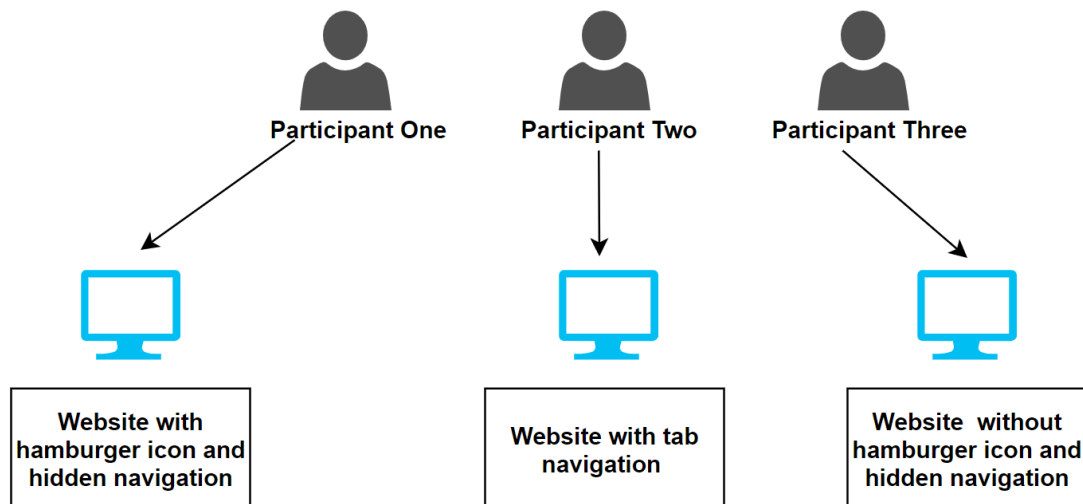
Figure 1:Between User Groups Experiment

The purpose of study is to find out the usability of hamburger icon and hidden navigation. It is challenging to find out the appropriate design experiment and users as it involves experiment among potentially large number of participants. Experimenting the same users with all the prototypes would potentially have learning effects and significant results supporting the study might be biased. To avoid this, it was felt that it is better if a single user is exposed to a single interface only, hence a between group was selected. The inclusion criteria of participants, however, was determined through pre-experiment questionnaires to avoid possibility of unequal level of experiences among the participants.

4.4 Prototype Development

A user prototype is a designed solution for candidate which is considered for a specific design problem(Pernice, 2016). A prototype could be realistic, detailed or even hand-sketched piece of paper; the choice of which depends upon the ultimate goal of testing, tools and resources available(Pernice, 2016). In this study, a web-based prototype was developed after formulating research questions, hypothesis which could lead to collection of valuable data from users to identify the cause and evaluate the navigation design which was under study.

Three different prototypes were designed with variation in navigation design. The prototypes were designed to emulate an actual website in terms of functionality, design, contents and use of icons and symbols. The popularity of hamburger menu could be because of its ability to scale many items(Tsiodoulos, 2016b). Online clothing store is a good testing case to scale many items too as it can have multiple categories, which is one of the reasons why the context of online clothing store was chosen. The maximum navigation level was four levels. Navigation level was increased to check the level of disorientation people might have when levels are hidden. All the prototypes had the same menu contents under the same categories. The context was an online clothing store for people.

4.4.1 Procedure of prototype development

The development of prototype involved various steps from understanding and using several other interfaces which had similar designs. Since it involved three different prototypes with different navigation designs, it was essential to use each of them, decide on the context to make it more user-friendly and familiar.

1. Study of existing similar navigation designs
   The primary step of prototype development was to study the navigation designs which existed already on web. The navigation designs of popular websites which had hamburger icon and hidden navigation, or tab navigation were studied to find out the standard design, maximum level of menus and the usability issues they might have.

2. Design a context.
   The necessity of a familiar context was felt after studying few existing applications available on internet. The potential candidates should feel familiarity in prototype and should be willing to use it. Considering these things, the prototype was given a context of online clothing store where users can view products under several categories. One of the reasons of choosing the context of online shopping was to have several levels of navigation to evaluate the impact of hidden navigation, for which online shopping would serve better with several categories and products.

3. Sketch a design and potential tasks.
   A sketch of prototype was made initially to give an outline to the prototype and context. It involved selection of categories, contexts, and menus. Different pages and how they should appear were also decided keeping in mind the potential task participants would do in the experiment. It also included the level of difficulty in each task which were modified later after prototype was developed.

4. Developing prototype

A prototype was developed based on sketch considering the tasks which participants will get. A web-based prototype using HTML, CSS, javascript and bootstrap framework was developed which resembled an online clothing store. Different pages, contents, clickable links and images were added to make it interactive.

5. Initial user evaluation

   The developed prototype went through a mockup test for initial user evaluation. Potential issues, technical errors and accessibility were tested in all three prototypes using various online tools as well as a heuristic approach was used to check the usability with the help of guidelines available. The heuristic evaluation was conducted following guidelines from Jakob Nielsen's usability heuristics for usability(Nielsen, 1994). User control and freedom, error prevention, match between real world and system, consistency and standards, help and prevention were few of the heuristic guidelines followed while evaluating the usability of the prototype.

6. Refining prototype and finalizing tasks

   After evaluating the prototype, potential errors and usability issues were amended and a well-refined prototype was made ready. The tasks which were initially designed were changed later in terms of difficulty because no significant difference in time was found initially with the designed tasks.

4.5 Navigation types used for study.

The primary focus of this study was to check the usability of hidden navigation and understandability of the hamburger icon itself. Based on previous literatures and subject matter of study, it was crucial to find out the usability of icon and replace the icon with informative text to measure the usability of icon itself. In addition, the usability of hidden navigation would be possible only after comparing the design with hidden navigation with a different navigation design, for which a tab navigation was selected.

4.5.1 Hidden navigation with hamburger icon

Hidden navigation with hamburger icon is a navigation design in which all the menus are hidden initially, and a hamburger icon represents the menu. Users need to click on the icon itself to expand the menu and it can be closed later by clicking on close icon. It has been achieved in the prototype by using JavaScript code to manipulate the HTML contents. A brief snippet of html content and JavaScript code block has been added in the appendix. (See appendix B)

4.5.2 Hidden navigation without hamburger Icon

The navigation design is a design approach in which all the menus are hidden. However, this alternative prototype contains an informative text instead of the icon itself. This approach has been developed to test and compare the usability and understandability of the icon, replacing the icon with an informative text- "MENU".

4.5.3 Tab navigation with mega dropdown menu

A tab navigation contains menu items listed in the form of tabs which can be seen on every page. Since this study checks usability of the menu designs, large number of menus of different levels were used. A menu designs with main categories on the top and the sub-menus under the main categories in the form of a mega dropdown with all the items appearing once was used as a different design. A code block with how it has been achieved is added in appendix (See appendix B).

No additional JavaScript code snippet was used for manipulation of navigation design of tab design. However, the menu expansion effect on click of category heading was obtained using CSS codes which have not been mentioned for brevity.

4.6 Technologies Used

Lenovo ideapad with Intel core I7 processor was used to develop the prototype. The operating system was windows 7 with 8 GB Radom Access Memory (RAM). A full functional web application was developed in the machine and the same project was copied to MacBook pro to avoid biasness in development and ensure platform compatibility of code. A fully functional static website was developed using asp.net

framework. The reason for choosing a programming framework was to make the development easier since the prototype required a lot of pages or menus and manually duplicating the code blocks and designs would consume a lot of time. A brief overview of tools used, programming languages and scripting languages used in the development of prototype are given below:

- Programming framework: ASP.NET MVC framework based on c sharp dotnet.
- Designing and project outline: HTML and CSS, Bootstrap classes
- Client-Side Scripting: JavaScript and jQuery plugins

4.7 Evaluation of Prototype

A good prototype is characterized by their creation, testing and iteration of design until it is good enough(Pernice, 2016). To ensure accessibility of the prototype, the prototype was evaluated using online accessibility evaluation tool known as "achecker". This tool checks HTML pages for conformance of accessibility standards to ensure that the contents are accessible for everyone(Gay & Li, 2010). All the pages of the three prototypes were evaluated using the same tool confirming the WCAG 2.0 Level AA.
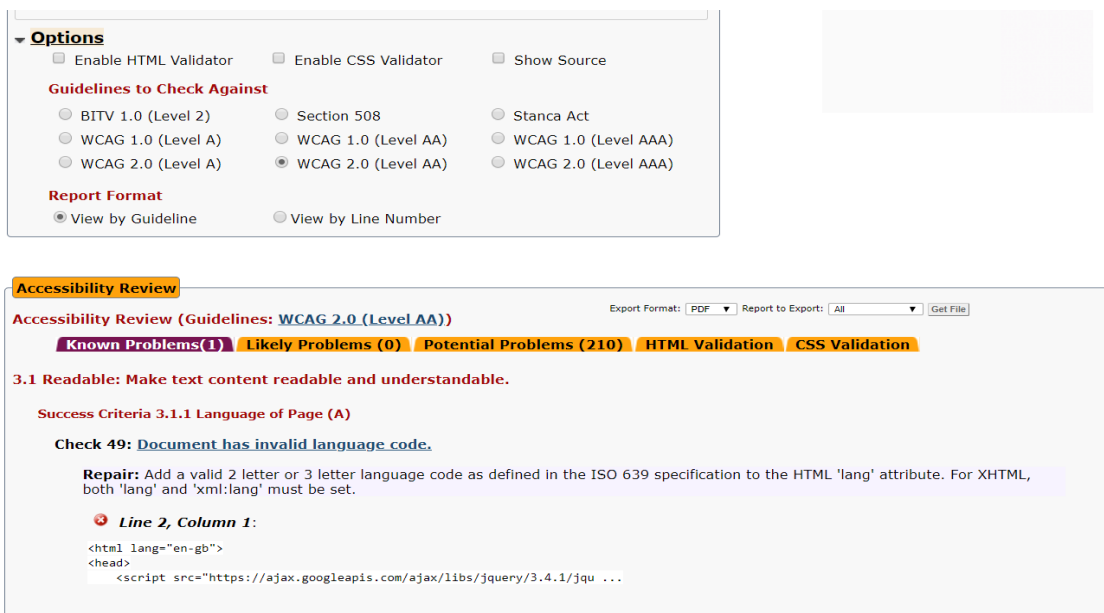
Figure 2:Initial Results of Accessibility Evaluation using achecker

After evaluating the pages using the tool, few issues were found which did not conform with the accessibility standards and guidelines. The issues were fixed and a detailed evaluation was carried out again to confirm the standards as suggested by evaluation tool.
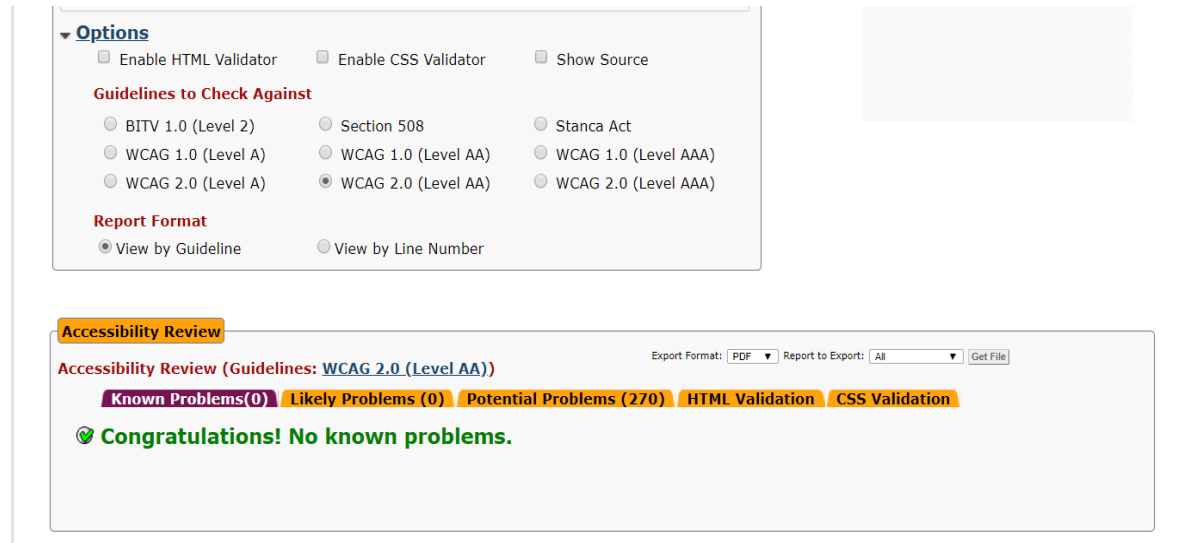
Figure 3: Results of Accessibility Evaluation using achecker after fixing issues.

The evaluation was conducted so that the prototype does not have any accessibility issues and does not violate any principles provided by international standards.

4.8 Prototype One: Hamburger navigation

The first prototype contains hidden navigation represented by hamburger icon. It is the primary prototype the study intends to get response from users to evaluate the usability. The context is an online clothing store. The home page contains a banner, a logo and an icon. Users have options to go to several links or pages using the navigation menu located on the left side in the form of icon. The second page is item listing page where users see a list of items with images and short description of each item. After users click on each item, a detail page is shown with a brief description about the item and detailed price. The navigation remains hidden and same for all the pages unless user clicks to expand the navigation and see menu.
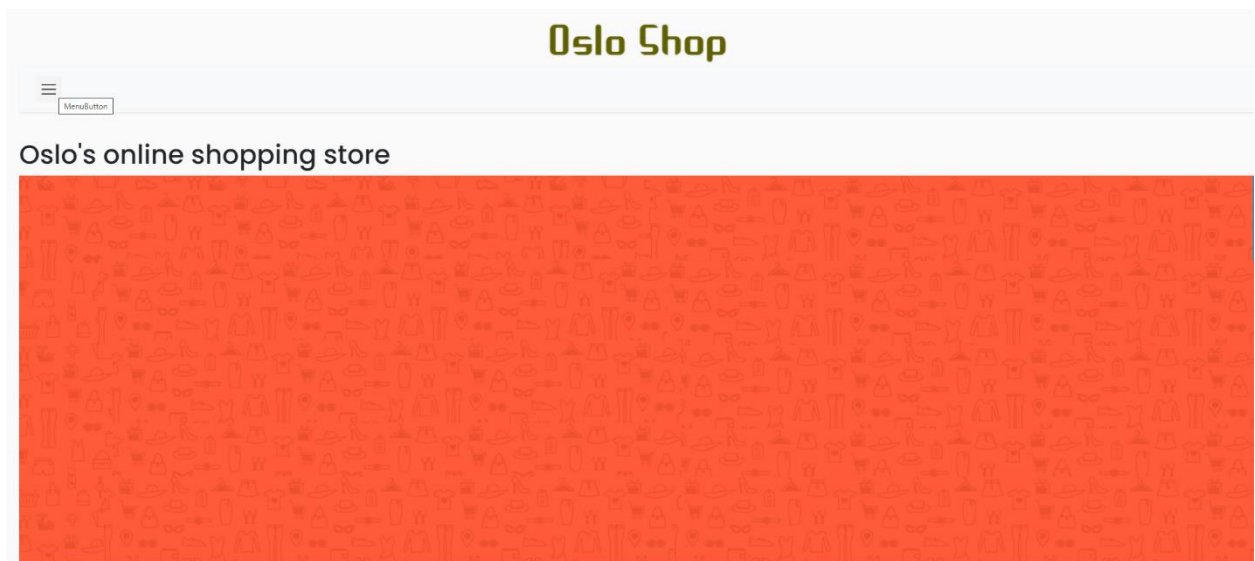
Figure 4:Menu design with Hamburger icon

Initially, the navigation menu is hidden. Users can see home page of the prototype website with hamburger icon and a picture along with logo.
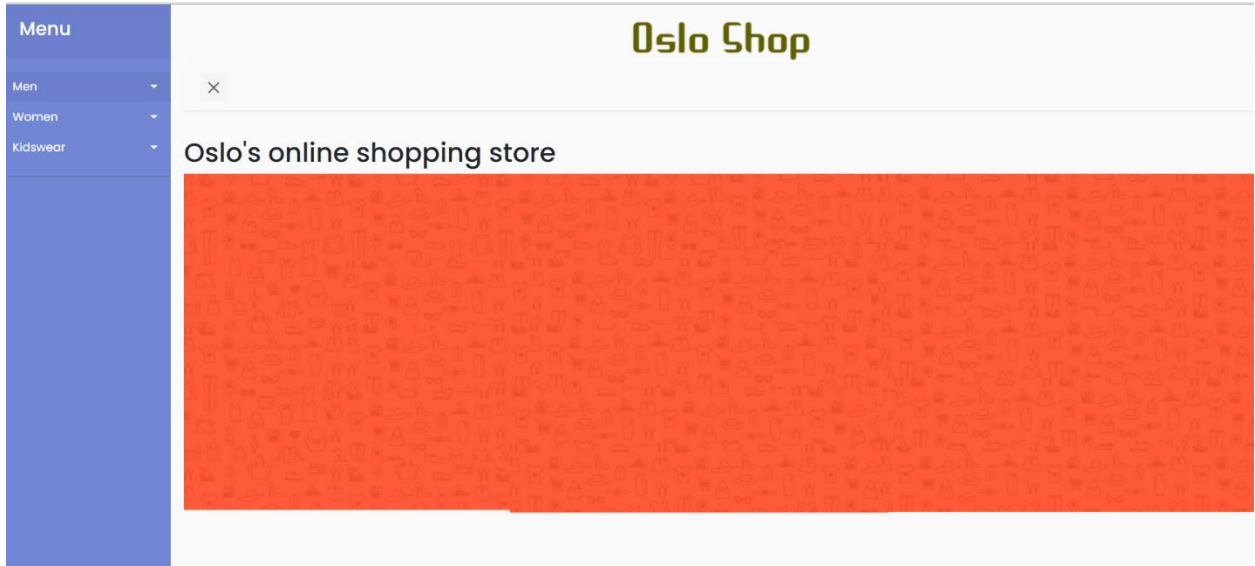
Figure 5:Menu design with navigation opened after clicking on hamburger icon

After user clicks on the icon, the hidden navigation is shown, and users can see menu along with categories. Users need to click on the categories to expand and find the links to other pages since some of the menus contain sub-menus as links to other pages. The sub-menus are also hidden according to the categories. The close icon can be used to close the menu and get back to the previous state.
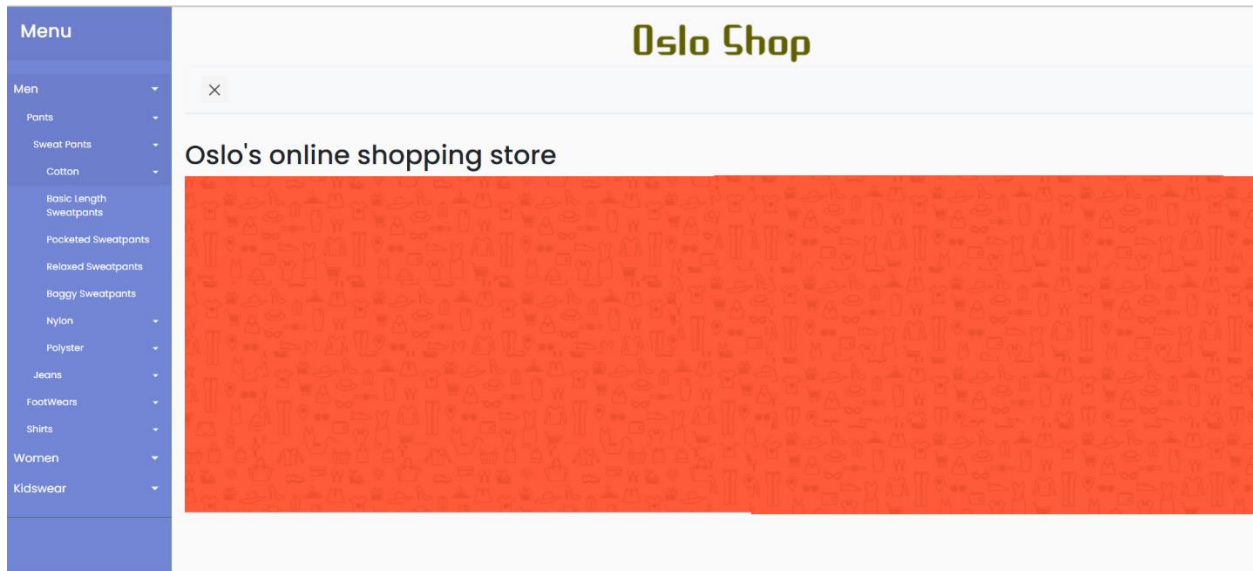
Figure 6: Menu design with hidden navigation expanded with four level navigation shown.

4.9 Prototype Two: Hidden navigation without icon

An alternative prototype without the metaphor "hamburger" icon but using a text "menu" to access the hidden navigation is designed.
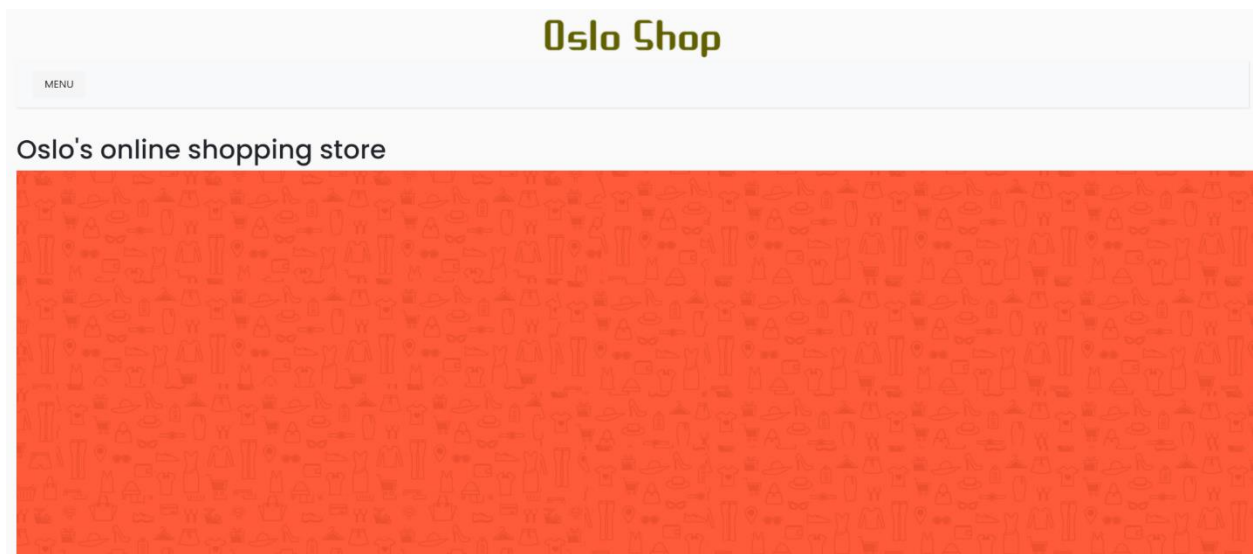
Figure 7:Menu Design with hidden navigation without the use of hamburger icon

The design is like the one with hamburger icon in which navigation is hidden. However, the "hamburger" icon has been replaced with an informative text "menu" that will help users to identify the main navigation. The contents and flow of links is similar to the prototype with hamburger icon and hidden navigation.

4.10 Prototype Three: Tab navigation

Mega menus are a type of expandable menu design in which many choices are displayed in two dimensional layout and everything can be seen once a menu handler is clicked or hovered (Neilsen, 2009).
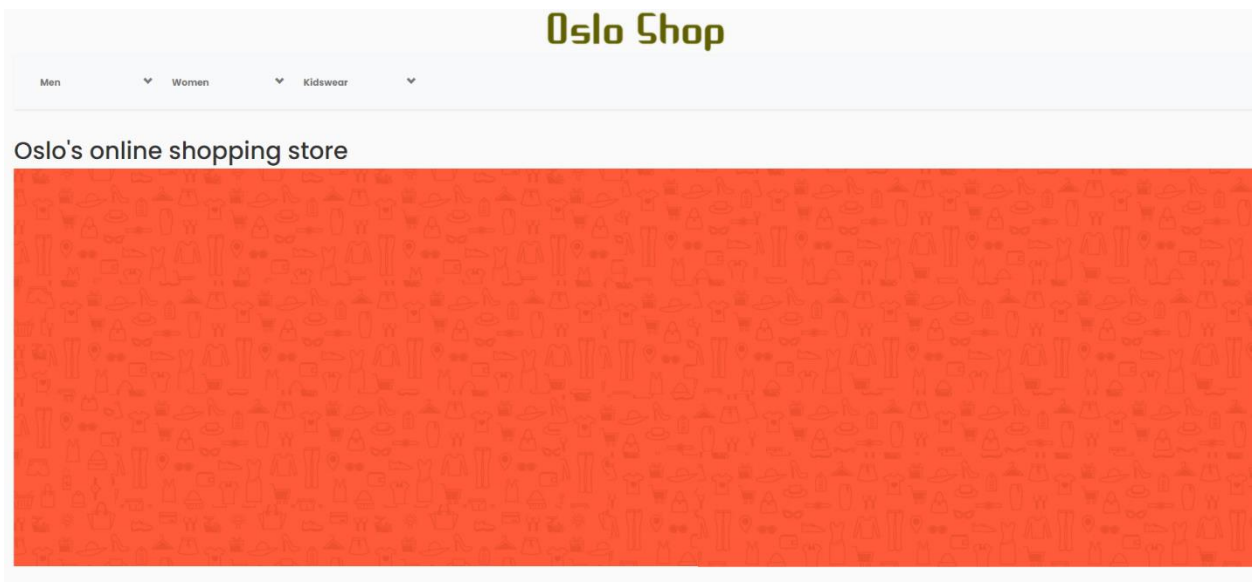
Figure 8:Menu design with tab navigation

Menu design with tab navigation shows primary three categories initially. Users must click on the primary categories to open sub-menus.
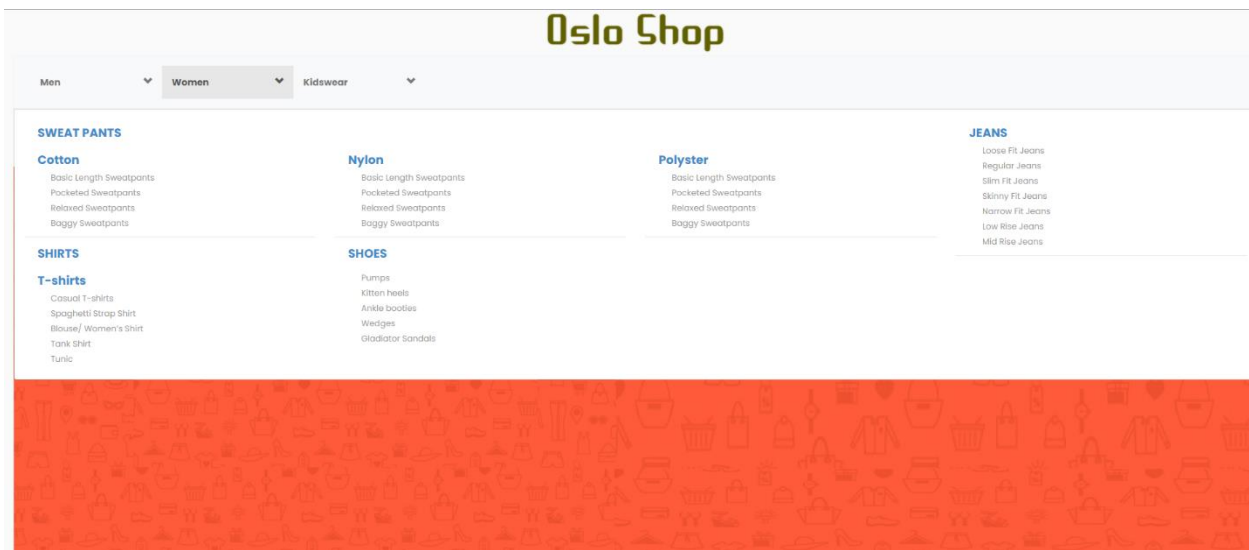
Figure 9:Menu design with expanded menu after a category is clicked

The sub-menus do not contain further hidden links and all the available menus under one category are seen at once. All the navigation links and page structures for the above-mentioned prototypes remain the same. Only the design of navigation has been altered for the study.

5. Data Collection

5.1 Participants

Participants were between the age from 20 to 40 The participants indicated that they had experience using online websites and mobile applications previously. A total of 45 participants were selected for the experiment (15 for each group). Since it was a between-group design experiment, the experiment venue was different according to participant's choice. The venue was in university study room in some cases, the researcher's own room or participant's place too in some cases depending upon the convenience. Participants were prior informed about the experimental design with an information sheet to make them aware about the experiment and study purpose. The date and time of experiment was confirmed with participant using various modes of communications like social media, text messaging or call.

During the experiment, it was made sure that there is only researcher and participant in the venue without any environmental disturbance. The recruitment process made sure that the participants had experience of using computer and mobile applications. The experience level of participants was obtained through pre-experiment questionnaires (See Appendix A) and those who did not have equal level of experience were omitted to ensure equivalence among them. The participants who had daily usage of internet, with experience of using both mobile and web applications for more than five years were taken into consideration for this study. Participants with a minimum education level of bachelor studies were only chosen for the experiment to maintain consistency in the education level.

5.2 Apparatus and Materials

Following are the apparatus and materials used for the experiment conducted:

1. A Lenovo Ideapad laptop with Windows 8 running, Intel core i7 processor, 8GB RAM and 18" screen size.
2. A stopwatch to record the total time taken.
3. Google Chrome as internet browser.

4. Three different prototypes which had the same contents but different menu designs.

5. A pre-experiment or recruitment questionnaire ([see recruitment questionnaires](#)).

6. A consent form before the experiment ([see consent form](#)).

7. An information sheet informing the participants about the research experiment procedure and outcomes ([see information sheet](#)).

8. A post experiment questionnaire to get feedback ([see post experiment questionnaire](#)).

9. Steps recorder: default program in windows to record screen and generate reports with timing.

5.3 Tasks

A total of six tasks were designed for the experiment. The tasks were designed to simulate a shopping website in which users can browse different items and look for items online, like online shopping. All the tasks were designed so that the users must use the navigation.

1. Please locate the main navigation link and Click to open the menu. Click on the logo to end this task.

2. Please navigate to **Tops** for **baby boy**. Then click on the logo to end this task.

3. Please navigate to **formal shirts** for **men**. Click on logo to end this task.

4. Please navigate to locate **kitten heel shoes** for **women**. Click on logo to end this task.

5. What is the **price** of **Pant Model Two** for **women** who likes **Regular Jeans**?

6. What is the **difference** between the **price** of **Cotton Pocketed Sweatpants** of **Cotton Relaxed Sweatpants** of **Pant Model Three** for **men**?

5.4 Procedure

5.4.1 Pre-experiment

All the participants were given an information sheet which contained detailed information about the study, its purpose, possible implications and benefits or risks involved (See Appendix) . After that, a consent form was provided in which participants had to sign and confirm that they are willing to take part in the experiment (See Appendix). After participants agreed to take part in the experiment, a pre-experiment questionnaire was provided to participant and asked to fill up. The pre-experiment questionnaire contained questions about demographic and basic information on usage of online applications (See Appendix).

5.4.2 Experiment

All the participants were allocated Groups A, B or C randomly until it reached equal number of users for each group. Group A represented website prototype with hidden navigation and hamburger icon, Group B represented hidden navigation without hamburger icon and hidden navigation, Group C represented tab navigation with mega-menu dropdown. The participants were given a brief training on the tasks and what the website represents. However, a detailed practical training on navigation usage was not given to the participants to avoid learning effects because this study focuses usability of navigation and it was assumed that providing a detailed training on navigation would possibly have learning effect on the participant which might impact the result as a whole.

The task list was given in printed form to the participants. The prototype was opened in Google Chrome browser using Lenovo ideapad laptop with 17-inch screen, Intel core I7 processor, except for 4 participants who preferred using their own computer for the experiment. These participants had windows 10 installed. Steps-recorder (default program available in windows Operating system) was started to record the steps and mouse clicks while participant performs the experiment with the tasks. A stopwatch was also started to measure the time and maintain accuracy, since steps-recorder also provided information about time as well. After steps recorder was started, participants

started to perform the tasks in order. During the time of task performance, doubts were cleared if the participants had any. After participants finished performing all the tasks, steps recorder was stopped, and stopwatch was also stopped.

5.4.3 Post-experiment

 A post-experiment questionnaire was provided to the participants which contained feedback questions and few questions regarding usability of the navigation (See Appendix). The participants were thanked for their participation and a chocolate bar was given as an expression of gratitude to the participants. The whole process was finished in an average of 15 minutes for each participant. During the whole experiment, a positive environment was maintained, and it was made sure that participants did not feel any sense of coercion while performing the experiment.

5.5 Ethical Considerations

It is well agreed that a research study should be ethical and harmless to users. The first international document which provided guidelines on ethics in research was Nuremberg Code (DeMatteo et al., 2005). Clinical research studies had voluntary consent as a requirement and a consent is voluntary only when participants are able to consent, free from any coercion and the participant understand any benefits and risks involved (DeMatteo et al., 2005). Numerous other principles and codes have been formulated later but all of them emphasize on protection and respect of human participations although these codes might differ across jurisdictions and disciplines.

Guidelines and rules regarding notification to NSD (Norwegian Centre for Research Data) was also studied prior to conducting the experiment and collecting data from users since the study was conducted within Norway. NSD is authorized data protection official body for all the Norwegian universities, colleges, research institutes and hospitals (NSD, 2019). The advice provided by NSD were studied in details and any clause to check whether the official body needs to be notified or not was carefully studied. Obtaining approval from NSD was not required for this project because personal data or anything else that could identify the participant was not collected. With

due respect to the principles and ethics, the following are the ethical considerations adapted by this study:

a. All the participants were made aware about the experiment and its purpose through an information sheet which contained information about the research, its purpose, activities involved, consequences in detailed manner.

b. A consent form was used to get a written consent of the participant prior to the experiment.

c. The experiment was free from any coercion and participants were well informed that they could withdraw the participation any time without any explanations.

d. The research did not involve any personal data since only the screen of the machine was recorded with prototype website opened in browser. It did not recognize participants in any manner.

e. The data collected from the experiment were used anonymously and no personal data were collected. However, demographical data about age-group, education level and level of experience of using internet was collected as it would be useful for the research.

The appendix section contains the details of information sheet provided to the participants (See Appendix).

6. Data Analysis and Result

The raw data collected in the data collection step was managed in excel sheet and was transferred to SPSS statistical tool to analyze it and to find the significance of data.

6.1 Participants Demographic Information

A total of 45 participants participated in the experiment with 12.5 % participants between age group of 30 to 35 years old and remaining 87.5% participants between age groups of 26 to 30 years old. A total of 37.5% of participants had education level of bachelor's level, while 62.5% of the participants had master's level of education.

 All the participants used internet in their daily lives, with 62.5% of participants familiar with online services since last 5 years, while the remaining had experience of using services available on internet for more than 10 years. All the participants agreed that they had experience of using both web as well as mobile applications.

6.2 Data analysis of participant's performance

A total of six tasks were given to participants, which were performed on one of the three prototypes provided to the participants during the experiment. The total time taken for completion of each task and errors made during each task were recorded through default screen recording tool provided by windows: steps-recorder. The unit of measurement of time was second. Since the experiment is between group, a test was conducted to find out whether the dependent variable scores are equally distributed across different independent groups. Although there are several methods that we can use to analyze normal distribution statistically, most used are Kolmogorov-Smirnov and Shapiro-Wilk tests to analyze the z-scores for skew and kurtosis, while counting the outliers of the collected data(Mayers, 2013).

6.2.1 Total task completion time

6.2.1.1   Test for normal distribution

Since the sample size for each task is 15, Shapiro-Wilk normality test is considered acceptable (Mayers, 2013) and hence the same test is performed for testing for normal distribution for the tasks and errors. Winsorizing to adjust the outliers (Ghosh & Vogt, 2012), was used to adjust data for task one (two records) and task five (one record), to adjust the outliers

Tasks	Menu Designs	Shapiro-Wilk		
		Statistic	df	Sig.
Task One	Hamburger menu design	.896	15	.082
	Hidden navigation without hamburger menu	.896	15	.082
	Tab Navigation	.883	15	.052
Task Two	Hamburger menu design	.915	15	.161
	Hidden navigation without hamburger menu	.960	15	.689
	Tab Navigation	.894	15	.077
Task Three	Hamburger menu design	.966	15	.798
	Hidden navigation without hamburger menu	.939	15	.370
	Tab Navigation	.960	15	.687
Task Four	Hamburger menu design	.903	15	.108
	Hidden navigation without hamburger menu	.961	15	.706

	Tab Navigation	.939	15	.372
Task Five	Hamburger menu design	.932	15	.291
	Hidden navigation without hamburger menu	.886	15	.058
	Tab Navigation	.976	15	.932
Task Six	Hamburger menu design	.894	15	.077
	Hidden navigation without hamburger	.974	15	.918
	Tab Navigation	.906	15	.117

Table 1:Tests for normal distribution for total time taken while completing tasks.

The normality test for total time taken while completing the tasks show that the data collected from the participants are normally distributed considering significant value of p>0.05.

6.2.1.2 Independent one-way ANOVA test

Since the data is normally distributed for total task completion time, an independent one-way ANOVA test is conducted to calculate the significance of the data collected. Since the sample size is equal, 15 for each group, selecting Tukey for post hoc was preferred safe and considering equality of variance, Games-Howel was also selected.

6.2.1.2.1 Task One

6.2.1.2.1.1   Descriptive Statistics

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		

Hamburger menu	15	3.4667	0.91548	0.23637	2.9597	3.9736	2	5.00
Hidden without hamburger	15	3.4000	0.98561	0.25448	2.8542	3.9458	2	5.00
Tab Navigation	15	2.4000	0.82808	0.21381	1.9414	2.8586	1	4.00
Total	45	3.0889	1.01852	0.15183	2.7829	3.3949	1	5.00

Table 2: Task one -Descriptive Statistics

The table shows that the mean time required to complete task one for menu design with hamburger icon appears to slightly higher than hidden navigation without hamburger icon, with difference of 0.06 seconds. It also shows that an average of 1 second of difference is between tab navigation design and hidden navigation design with hamburger icon, with tab navigation design being the fastest.

6.2.1.2.1.2 Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
0.322	2	42	0.726

Table 3:Task One- Test for homogeneity of variances

The test for homogeneity of variance for task one using Levene statistics shows that the significance is 0.726, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.1.2.1.3 ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	10.711	2	5.356	6.439	0.004	
Within Groups	34.933	42	0.832			
Total	45.644	44				

Table 4: Task One- Anova Statistics

The ANOVA statistics from task 1 shows that there is a mean difference in total time required to complete the task across different menu designs. It is reported as F(2,42)=6.439. The significance value is 0.004 which is less than 0.05, a significant difference in somewhere around the means is felt in between dependent variables in our three groups. But it does not tell us which group is different from which other groups. To find the actual difference, a post hoc analysis is carried out.

Dependent Variable:	Total Time						
(I) Auto Recoded			Mean Diff (I-J)	Std. Error	Sig.	95% Conf. Interval	
						Lower Bound	Upper Bound
Tukey HSD	Hamburger menu	Hidden without hamburger	.06667	.3330	.978	-.7424	.8757
		Tab Navigation	1.06667*	.3330	.007	0.2576	1.875

	Hidden without hamburger	Hamburger menu	-0.06667	.3330	.978	-0.8757	.7424
		Tab Navigation	1.00000*	.3330	.012	0.1909	1.809
	Tab Navigation	Hamburger menu	-1.06667*	.3330	.007	-1.8757	-.2576
		Hidden without hamburger	-1.00000*	.3330	.012	-1.8091	-.1909
Games-Howell	Hamburger menu	Hidden without hamburger	0.06667	.3473	.980	-0.7930	.9263
		Tab Navigation	1.06667*	.3187	.006	0.2776	1.855
	Hidden without hamburger	Hamburger menu	-0.06667	.3473	.980	-.9263	.7930
		Tab Navigation	1.00000*	.3323	.015	.1762	1.823
	Tab Navigation	Hamburger menu	-1.06667*	.3187	.006	-1.8557	-.2776
		Hidden without hamburger	-1.00000*	.33238	.015	-1.8238	-.1762

44

Table 5: Task One-Post hoc analysis

The groups with asterisks show that there is significantly difference between groups with an alpha level of 0.05. The exact significant level is seen in the column sig. The hamburger navigation design is statistically different to tab design but not with hidden navigation without hamburger, making it slower than tab navigation by 1.067 seconds. The hidden navigation without hamburger is also not statistically significant with hamburger navigation but is different with tab navigation. Likewise, the tab navigation is also statistically significant to both hamburger and hidden without hamburger navigation design, making it faster by approximately 1 seconds comparing to both hidden navigation patterns.

6.2.1.2.1.4   Means Plot
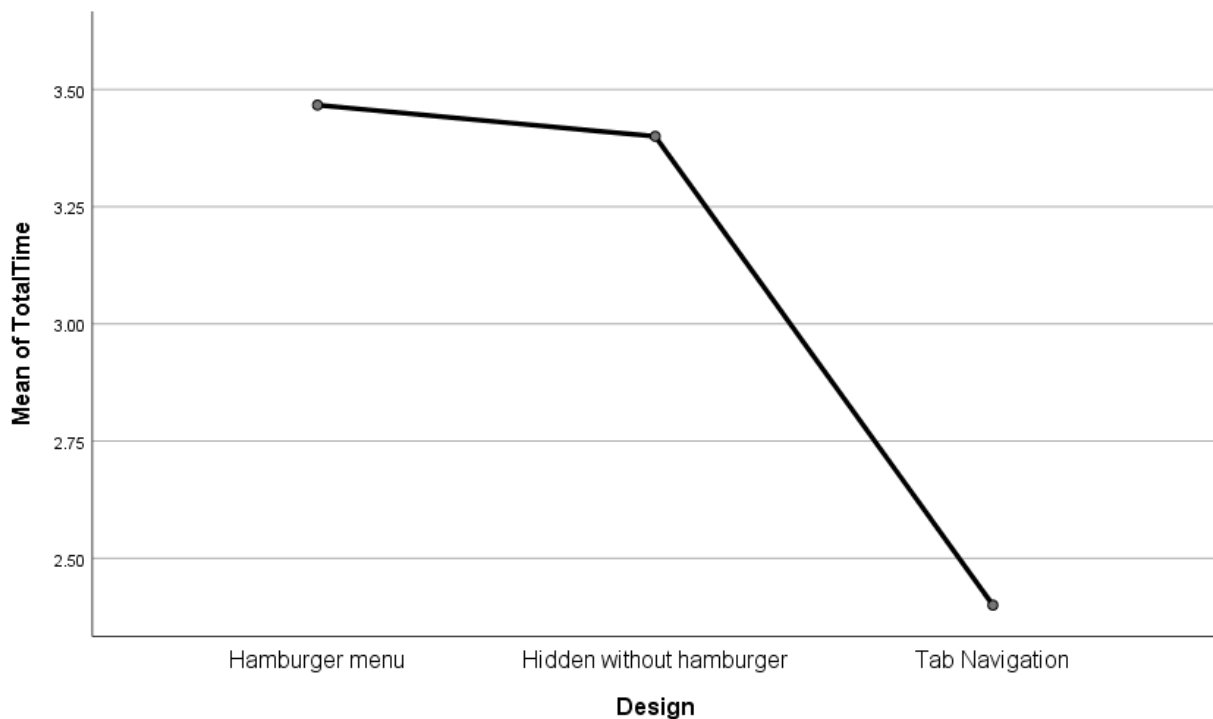
Figure 10: Task One- Means Plot

The means plot shows that the average time for task one is fastest for tab navigation and hidden navigation with hamburger menu is the slowest one with a difference of around 1 seconds.

6.2.1.2.2 Task Two

6.2.1.2.2.1 Descriptive Statistics

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Hamburger menu	15	8.3333	2.43975	0.62994	6.9822	9.6844	5.00	14.00
Hidden without hamburger	15	9.1333	2.03072	0.52433	8.0088	10.2579	5.00	13.00
Tab Navigation	15	7.8667	1.40746	0.36341	7.0872	8.6461	6.00	10.00
Total	45	8.4444	2.02883	0.30244	7.8349	9.0540	5.00	14.00

Table 6: Task two - descriptive statistics

The table shows that the average time taken to complete task two for hidden navigation without hamburger icon is higher than the remaining two navigation designs. The average time is 9.13 seconds for design two and 8.33 seconds for design one. However, the mean value is 7.87 seconds only for tab navigation design.

6.2.1.2.2.2 Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
1.467	2	42	0.242

Table 7: Task two- test for homogeneity of variance

The test for homogeneity of variance for task two using Levene statistics shows that the significance is 0.242, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.1.2.2.3   ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.311	2	6.156	1.532	.228
Within Groups	168.800	42	4.019		
Total	181.111	44			

Table 8: Task two- Anova Statistics

The ANOVA statistics from task 2 shows that the significance value is 0.228 which is more than 0.05. Hence, no significant difference in somewhere around the means is felt in between dependent variables in our three groups.

6.2.1.2.2.4　Means Plot
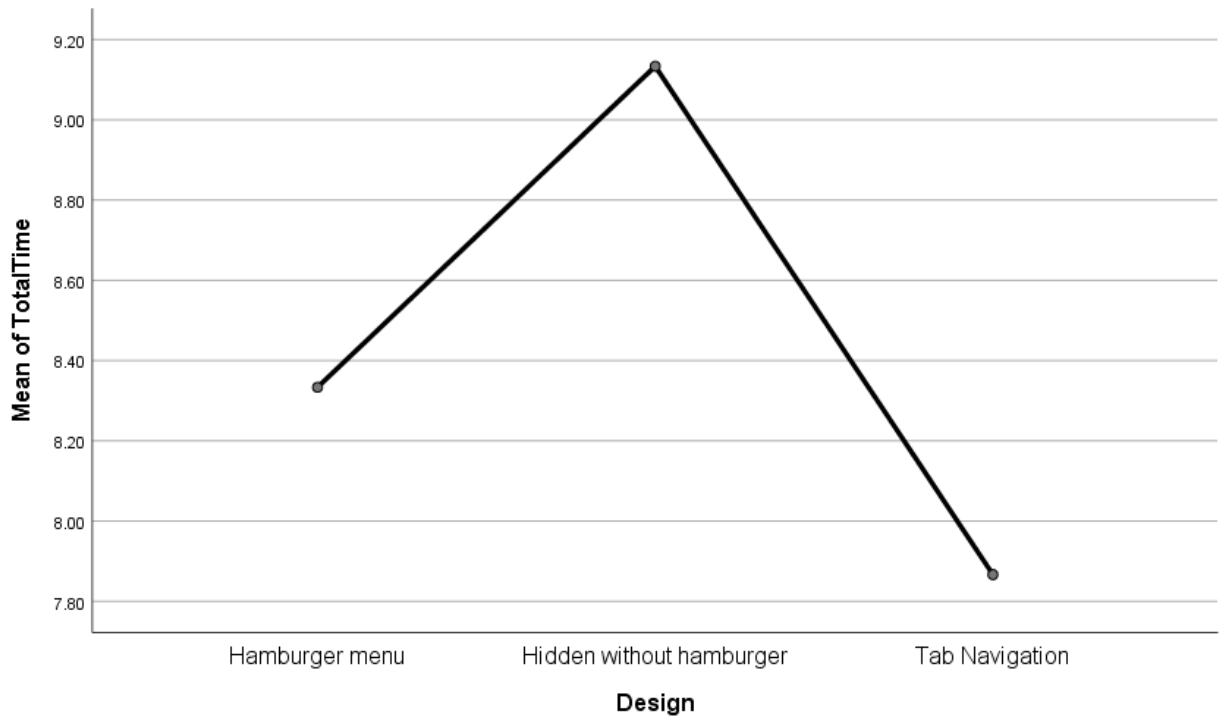
Figure 11: Task two- Means Plot

The average time for hidden navigation without hamburger icon is the slowest one with around 9.1 seconds, followed by hamburger menu design with 8.3 seconds and tab navigation design with around 7.9 seconds.

6.2.1.2.3　Task Three

6.2.1.2.3.1　Descriptive Statistics

Menu design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	Upper Bound	Min	Max
					Lower Bound			

Hamburger menu	15	7.3333	1.91485	0.49441	6.2729	8.3937	4.00	11.00
Hidden without hamburger	15	8.7333	2.05171	0.52975	7.5971	9.8695	6.00	13.00
Tab Navigation	15	7.4667	1.68466	0.43498	6.5337	8.3996	4.00	11.00
Total	45	7.8444	1.95350	0.29121	7.2575	8.4313	4.00	13.00

Table 9: Task three- Descriptive Statistics

The table shows that the average time taken to complete task three for hidden navigation without hamburger icon is higher than the remaining two navigation designs. The average time is 7.3 seconds for hamburger navigation and 8.73 seconds for hidden navigation without hamburger. Likewise, it is 7.46 seconds for tab navigation.

6.2.1.2.3.2   Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
0.303	2	42	0.740

Table 10:Task three- Test for homogeneity of variances

The test for homogeneity of variance for task three using Levene statistics shows that the significance is 0.740, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.1.2.3.3   ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	17.911	2	8.956	2.508	0.094
Within Groups	150.000	42	3.571		
Total	167.911	44			

Table 11: Task three- Anova Statistics

The ANOVA statistics from task 3 shows that the significance value is 0.094 which is more than 0.05. Hence, statistically no significant difference in somewhere around the means is felt in between dependent variables in our three groups.

6.2.1.2.3.4   Means Plot
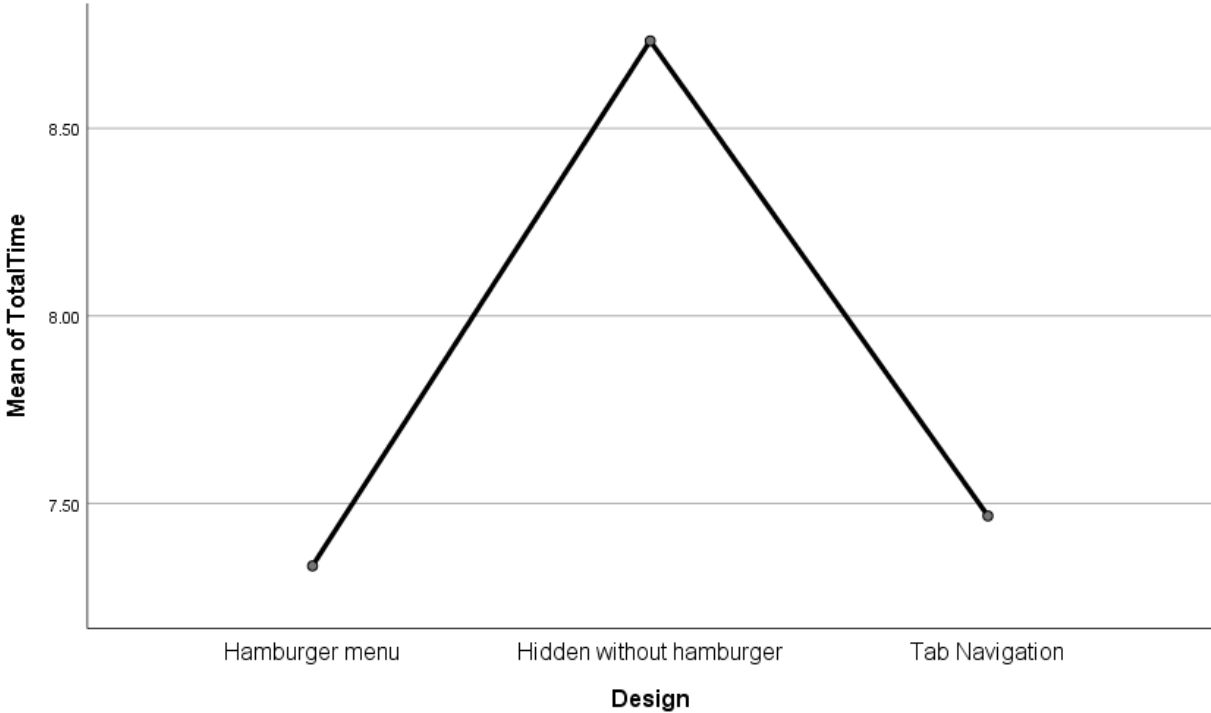
Figure 12: Task three- Means Plot

The means plot for task three shows that hamburger menu design and tab navigation both have almost same performance with an average of around 7.3 and 7.4 seconds, respectively. The hidden navigation without hamburger icon is slowest with an average time of around 9 seconds.

6.2.1.2.4 Task Four

6.2.1.2.4.1   Descriptive Statistics

Menu Design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Hamburger menu	15	8.3333	2.09307	0.54043	7.1742	9.4924	3.00	11.00
Hidden without hamburger	15	9.4000	1.72378	0.44508	8.4454	10.3546	6.00	12.00
Tab Navigation	15	8.4667	1.45733	0.37628	7.6596	9.2737	5.00	11.00
Total	45	8.7333	1.80151	0.26855	8.1921	9.2746	3.00	12.00

Table 12: Task Four- Descriptive Statistics

The table shows that the average time taken to complete task four for hidden navigation without hamburger icon is higher than the remaining two navigation designs. The average time is 9.4 seconds for hidden navigation without hamburger icon and 8.33 seconds for hamburger navigation design. However, the mean value is 8.46 seconds for tab navigation design.

6.2.1.2.4.2   Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
.808	2	42	0.452

The test for homogeneity of variance for task four using Levene statistics shows that the significance is 0.452, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.1.2.4.3   ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.133	2	5.067	1.604	.213
Within Groups	132.667	42	3.159		
Total	142.800	44			

Table 14: Task Four- Anova Statistics

The ANOVA statistics from task four shows that the significance value is 0.213 which is more than 0.05. Hence, statistically no significant difference in somewhere around the means is felt in between dependent variables in our three groups.

6.2.1.2.4.4   Means Plot
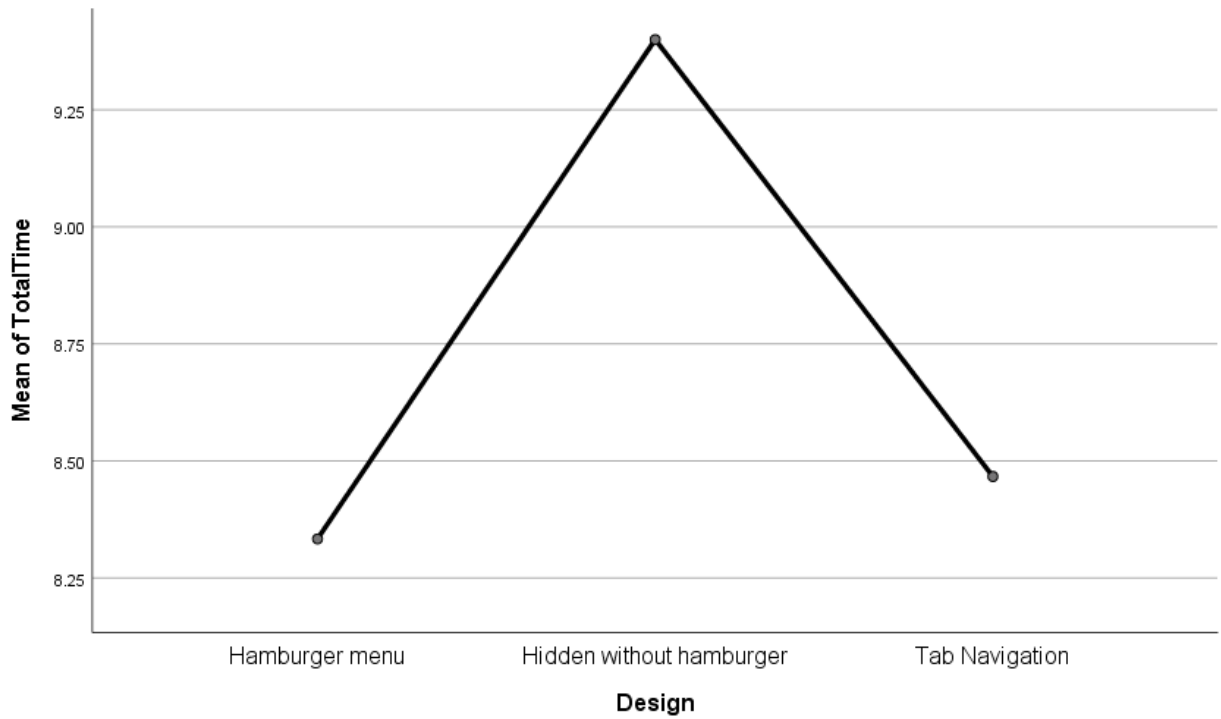
Figure 13: Task Four- Means Plot

The average task completion time for task four is slowest for hidden navigation design without hamburger icon, whereas, both tab navigation and hamburger navigation design have almost same performance time with around 8.4 seconds and 8.3 seconds, respectively.

6.2.1.2.5 Task Five

6.2.1.2.5.1   Descriptive Statistics

Menu Design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		

Hamburger menu	15	11.0667	2.12020	.54743	9.8925	12.2408	8	15
Hidden without hamburger	15	10.6000	2.26148	.58391	9.3476	11.8524	8	15
Tab Navigation	15	9.8000	2.04241	.52735	8.6690	10.9310	6	14
Total	45	10.4889	2.15978	.32196	9.8400	11.1378	6	15

Table 15: Task Five-Descriptive Statistics

The table shows that the average time taken to complete task five for hidden navigation without hamburger icon is higher than the remaining two navigation designs. The average time is 11.067 seconds for navigation design with hamburger icon and 10.6 seconds for hidden navigation without hamburger icon. However, the mean value is 9.80 seconds only for tab navigation design.

6.2.1.2.5.2   Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
0.379	2	42	0.687

Table 16:Task five -Test for homogeneity of variances

The test for homogeneity of variance for task two using Levene statistics shows that the significance is 0.697, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.1.2.5.3   ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	12.311	2	6.156	1.340	.273
Within Groups	192.933	42	4.594		
Total	205.244	44			

Table 17: Task five- Anova Statistics

The ANOVA statistics from task 2 shows that the significance value is 0.273 which is more than 0.05. Hence, statistically no significant difference in somewhere around the means is felt in between dependent variables in our three groups.

6.2.1.2.5.4   Means Plot
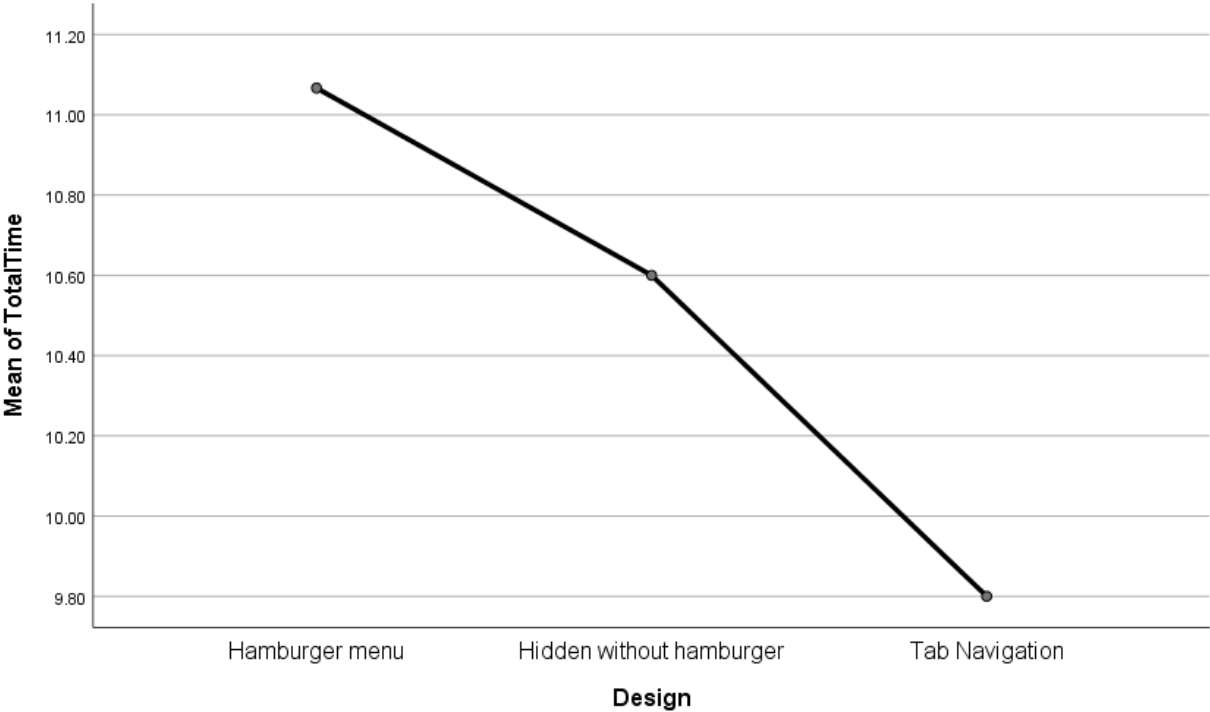
Figure 14:Task five- Means Plot

The means plot for total task completion time of task five shows that tab navigation was the fastest one with an average of 9.8 seconds, followed by hidden navigation without hamburger icon with an average of 10.60 seconds. The hamburger menu design has the slowest performance with an average of 11 seconds of task completion time.

6.2.1.2.6 Task Six

6.2.1.2.6.1   Descriptive Statistics

Menu design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Hamburger menu	15	93.466	13.91231	3.5921	85.7623	101.1710	70	114
Hidden without hamburger	15	90.933	16.30279	4.2093	81.9051	99.9615	61	120
Tab Navigation	15	57.266	12.97507	3.3501	50.0813	64.4520	22	76
Total	45	80.555	21.86691	3.2597	73.9860	87.1251	22	120

Table 18: Task Six- Descriptive Statistics

The table shows that the average time taken to complete task six for hidden navigation with hamburger icon is higher than the remaining two navigation designs. The average time is 93.46 seconds for hidden navigation with hamburger one and 90.933 seconds for design two. The mean value for tab navigation is 57.26 seconds for tab navigation

which is around 36 seconds less than hamburger design and 33 seconds less than hidden navigation design without hamburger icon.

6.2.1.2.6.2   Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
0.805	2	42	0.545

Table 19: Task Six- Test for homogeneity of variance

The test for homogeneity of variance for task two using Levene statistics shows that the significance is 0.545, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.1.2.6.3   ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12251.511	2	6125.756	29.278	0.001
Within Groups	8787.600	42	209.229		
Total	21039.111	44			

Table 20: Task Six- Anova Statistics

The ANOVA statistics from task six shows that there is a mean difference in total time required to complete the task across different menu designs. It is reported as F(2,42)=29.278 The significance value is 0.001 which is less than 0.05. Hence, a significant difference in somewhere around the means is felt in between dependent variables in our three groups.

6.2.1.2.6.4   Means Plot
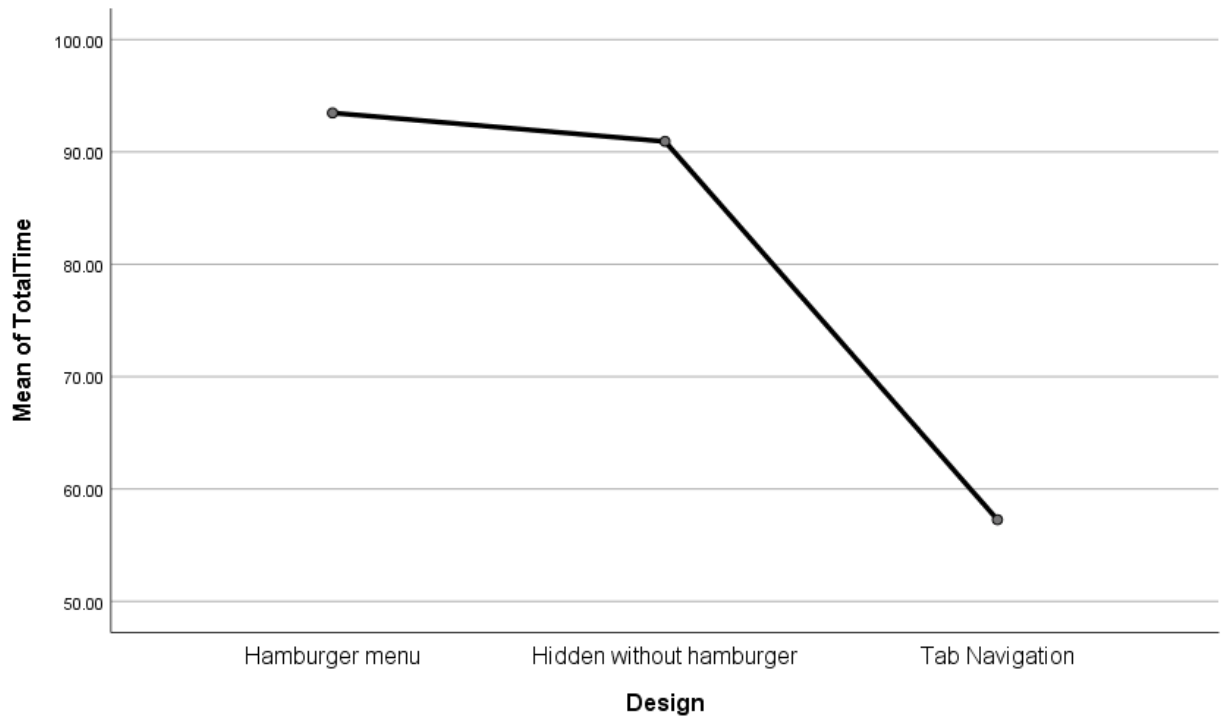
Figure 15: Task Six- Means Plot

The means plot for task six shows that the average task completion time for hamburger menu design and hidden navigation design without hamburger icon are approximately same with an average of 90 seconds. However, the menu design with tab navigation is drastically faster for task six with an average of around 60 seconds.

6.2.1.2.6.5 Post hoc analysis.

Dependent Variable:	Total Time						
Menu Design			Mean Diff. (I-J)	Std. Error	Sig.	95% Conf. Interval	
						Lower Bound	Upper Bound
Tukey HSD	Hamburger menu	Hidden without hamburger	2.53333	5.2817	.88	-10.2987	15.365
		Tab Navigation	36.2000*	5.2817	.00	23.3680	49.032
	Hidden without hamburger	Hamburger menu	-2.53333	5.2817	.88	-15.3654	10.298
		Tab Navigation	33.6667*	5.2817	.00	20.8346	46.498
	Tab Navigation	Hamburger menu	-36.200*	5.2817	.00	-49.0320	-23.36
		Hidden without hamburger	-33.667*	5.2817	.00	-46.4987	-20.83

Games-Howell	Hamburger menu	Hidden without hamburger	2.53333	5.5337	.89	-11.1778	16.244
		Tab Navigation	36.2000*	4.9119	.00	24.0429	48.357
	Hidden without hamburger	Hamburger menu	-2.53333	5.5337	.89	-16.2444	11.177
		Tab Navigation	33.6667*	5.3798	.00	20.3181	47.015
	Tab Navigation	Hamburger menu	-36.200*	4.9119	.00	-48.3571	-24.04
		Hidden without hamburger	-33.6667*	5.3798	.00	-47.0153	-20.318

Table 21: Task Six- Post hoc analysis

The groups with asterisks show that there is significantly difference between groups with an alpha level of 0.05. The exact significant level is seen in the column sig. The tab navigation design is statistically significant with both hidden navigation designs with and without hamburger icon. The difference in average time taken to complete tasks is around 36 seconds between hamburger design navigation and tab navigation design. Likewise, there is a difference of about 33 seconds in average time taken to complete the tasks between tab navigation and hidden navigation without hamburger icon. Statistically, the average time taken to complete task six for tab navigation is statistically less than the remaining two designs with hidden navigation.

6.2.1.3 Result Analysis of Total task completion time

Some significant difference is observed for task 1 (locating the main navigation menu) and task 6 (finding price difference between two items) while conducting post hoc analysis. It is observed that an average of 1 second of difference occurs between tab navigation design and the remaining two designs with hidden navigation while locating the main navigation design. Likewise, for task six, it is observed that the tab navigation design has faster completion time, with an average of 36 seconds of difference with hidden navigation with hamburger icon and an average of 33 seconds of difference is found with design without hamburger icon.

Statistically no significant difference is seen in total task completion time for task 2, 3, 4 and 5. The means plot, however, shows that for task 5 the total task completion less for tab navigation design with mega-dropdown menus (around 2 seconds less than hidden navigation with hamburger and 1 seconds less than the second design). Likewise, for task 2, the difference is around 2 seconds while comparing with the remaining two designs. It is observed that for task 3 and task 4, the average task completion time for hamburger menu design is 1 seconds less than the hidden navigation design without hamburger icon, and around 0.5 seconds less than the tab navigation design with mega-dropdown menus.

6.2.2 Total Number of Errors

6.2.1.4   Tests for Normal Distribution

Tasks	Menu Design	Shapiro-Wilk		
Task One		Statistic	df	Sig.
	Hamburger menu	.889	15	.064
	Hidden without hamburger icon	.883	15	.052
	Tab Navigation	.888	15	.063
Task Two	Hamburger menu	.891	15	.070
	Hidden without hamburger icon	.888	15	.063
	Tab Navigation	.881	15	.050
Task Three	Hamburger menu	.891	15	.070
	Hidden without hamburger icon	.925	15	.231
	Tab Navigation	.883	15	.052
Task Four	Hamburger menu	.917	15	.175
	Hidden without hamburger icon	.915	15	.159
	Tab Navigation	.883	15	.052
Task Five	Hamburger menu	.896	15	.082

	Hidden without hamburger icon	.896	15	.082
	Tab Navigation	.883	15	.052
Task Six	Hamburger menu	.931	15	.286
	Hidden without hamburger icon	.919	15	.188
	Tab Navigation	.929	15	.266

Table 22:Test for normal distribution for total number of errors

6.2.1.5 Independent One-way ANOVA test

6.2.2.2.1 Errors in Task One

6.2.2.2.1.1 Descriptive Statistics

Menu design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Hamburger menu	15	1.47	1.060	0.274	0.88	2.05	0	3
Hidden without hamburger	15	1.40	0.828	0.214	0.94	1.86	0	3

Tab Navigation	15	1.27	0.884	0.228	0.78	1.76	0	3
Total	45	1.38	0.912	0.136	1.10	1.65	0	3

Table 23: Task One Errors- Descriptive Statistics

The table shows that the mean errors occurred while completing task one for menu design with hamburger icon appears to slightly higher than hidden navigation without hamburger icon, with difference of 0.07 errors. It also shows that an average difference of 0.20 of errors is between tab navigation design and hidden navigation design with hamburger icon.

6.2.2.2.1.2 Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
0.847	2	42	0.436

Table 24: Task One Errors- Test for homogeneity of variances.

The test for homogeneity of variance for errors occurred while performing task one using Levene statistics shows that the significance is 0.436, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.2.2.1.3 ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.311	2	.156	.180	.836
Within Groups	36.267	42	.863		

Total	36.578	44			

Table 25:Task One Errors- Anova Statistics

The ANOVA statistics from task 1 shows that there is a mean difference in total errors while completing task 1 across different menu designs. It is reported as $F_{(2,42)}=.180$ The significance value is 0.836 which is more than 0.05. Hence no significant difference in total number of errors while performing task one is found.

6.2.2.2.1.4   Means Plot
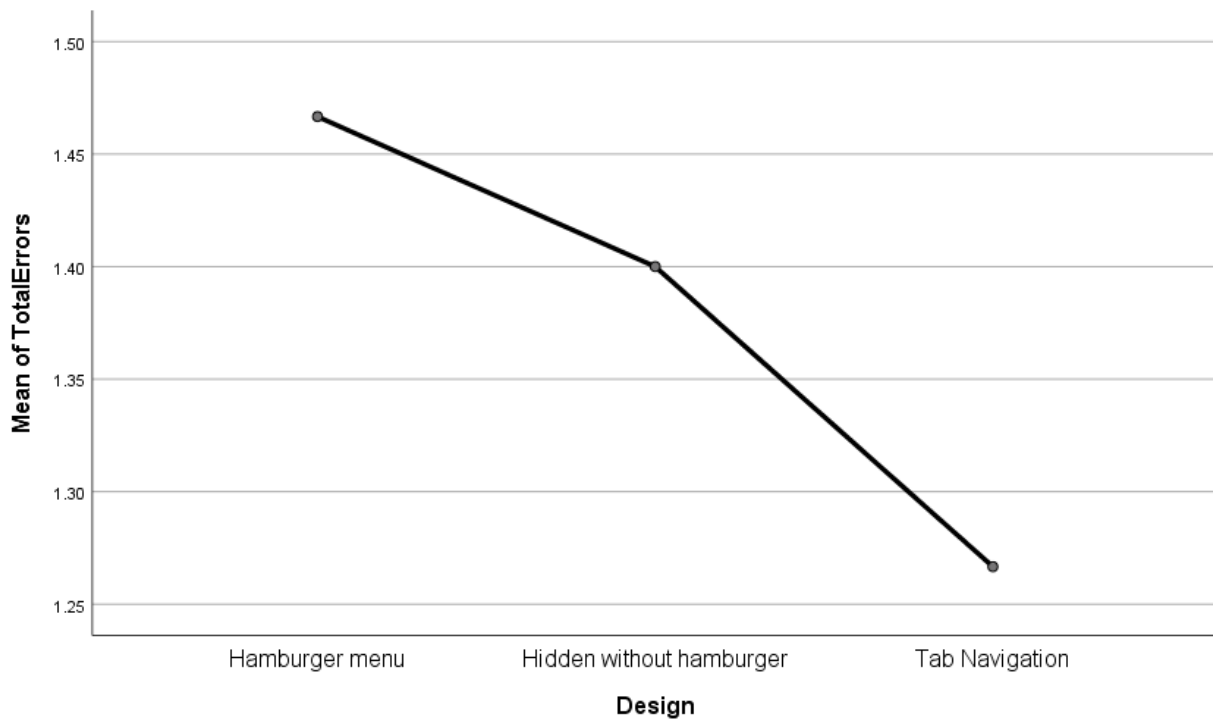
Figure 16: Task One Errors- Means Plot

The average error rate for task one is less for tab navigation design and highest for hamburger menu design with an average of 1.25 seconds and 1.45 seconds, respectively.

6.2.2.2.2 Errors in Task Two

6.2.2.2.2.1   Descriptive Statistics

Menu design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Hamburger menu	15	1.33	0.976	0.252	0.79	1.87	0	3
Hidden without hamburger	15	1.27	0.884	0.228	0.78	1.76	0	3
Tab Navigation	15	1.13	0.915	0.236	0.63	1.64	0	3
Total	45	1.24	0.908	0.135	0.97	1.52	0	3

Table 26: Task two Errors- Descriptive Statistics

The table shows that the mean errors occurred while completing task two for menu design with hamburger icon appears to slightly higher than hidden navigation without hamburger icon, with difference of 0.06 errors. It also shows that an average difference of 0.1 errors between tab navigation design and hidden navigation design with hamburger icon.

6.2.2.2.2.2   Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
0.137	2	42	0.873

Table 27: Task two errors- test for homogeneity of variances

The test for homogeneity of variance for errors occurred while performing task one using Levene statistics shows that the significance is 0.873, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.2.2.2.3 ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.311	2	.156	.181	.835
Within Groups	36.000	42	.857		
Total	36.311	44			

Table 28: Task two errors- Anova Statistics

The ANOVA statistics from task 2 shows that there is a mean difference in total errors occurred to complete the task 2 across different menu designs. It is reported as $F(2,42)=.181$ The significance value is 0.835 which is more than 0.05. Hence no significant difference in total number of errors while performing task one is found.

6.2.2.2.2.4   Means Plot
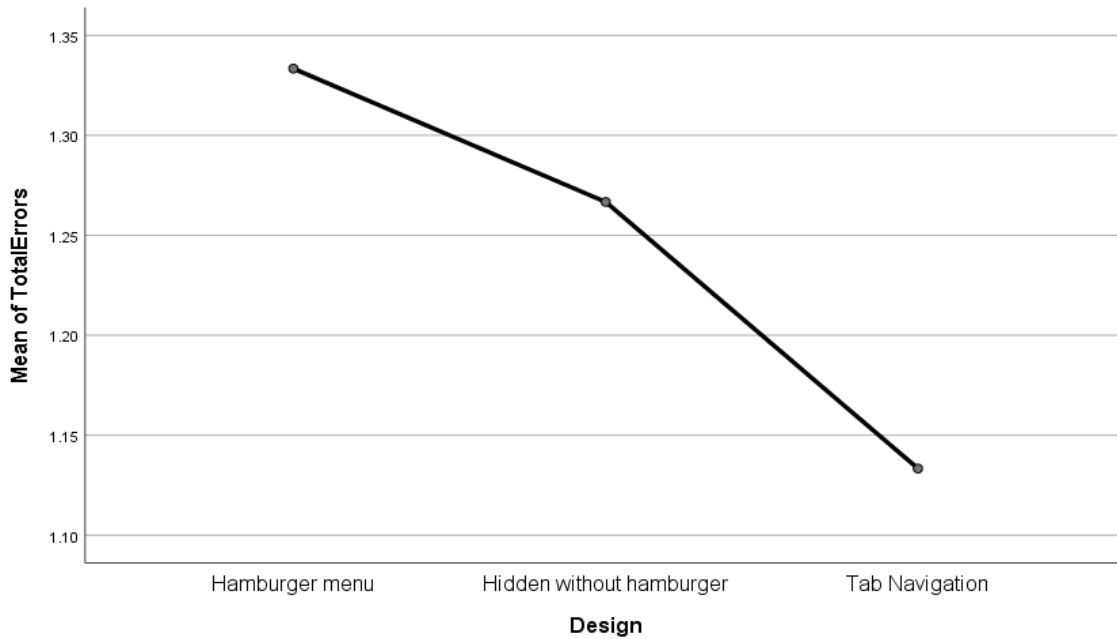
Figure 17: Task two errors- Means Plot

The average error for task two is highest for hamburger menu design, followed by hidden navigation design without hamburger icon and tab navigation design with an average error rate of 1.3, 1.2 and 1.1 respectively.

6.2.2.2.3 Errors in Task Three

6.2.2.2.3.1   Descriptive Statistics

Menu design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Hamburger menu	15	1.67	0.976	0.252	1.13	2.21	0	3

68

Hidden without hamburger	15	1.87	1.457	0.376	1.06	2.67	0	5
Tab Navigation	15	1.40	0.828	0.214	0.94	1.86	0	3
Total	45	1.64	1.111	0.166	1.31	1.98	0	5

Table 29: Task three errors- Descriptive Statistics

The table shows that the mean errors occurred while completing task three for menu design with hidden navigation without hamburger icon appears to slightly higher than the remaining two designs, with a difference of 0.47 errors with tab navigation and 0.20 errors with hamburger menu design.

6.2.2.2.3.2   Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
1.508	2	42	0.233

Table 30: Task three errors- test for homogeneity of variances

The test for homogeneity of variance for errors occurred while performing task three using Levene statistics shows that the significance is 0.233, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.2.2.3.3   ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.644	2	.822	.656	.524

Within Groups	52.667	42	1.254		
Total	54.311	44			

<div align="center">Table 31: Task three errors- Anova Statistics</div>

The ANOVA statistics from task 3 shows that there is a mean difference in total errors occurred while completing task 3 across different menu designs. It is reported as $F(2,42)=.656$ The significance value is 0.524 which is more than 0.05. Hence no significant difference in total number of errors while performing task one is found.

6.2.2.2.3.4   Means Plot
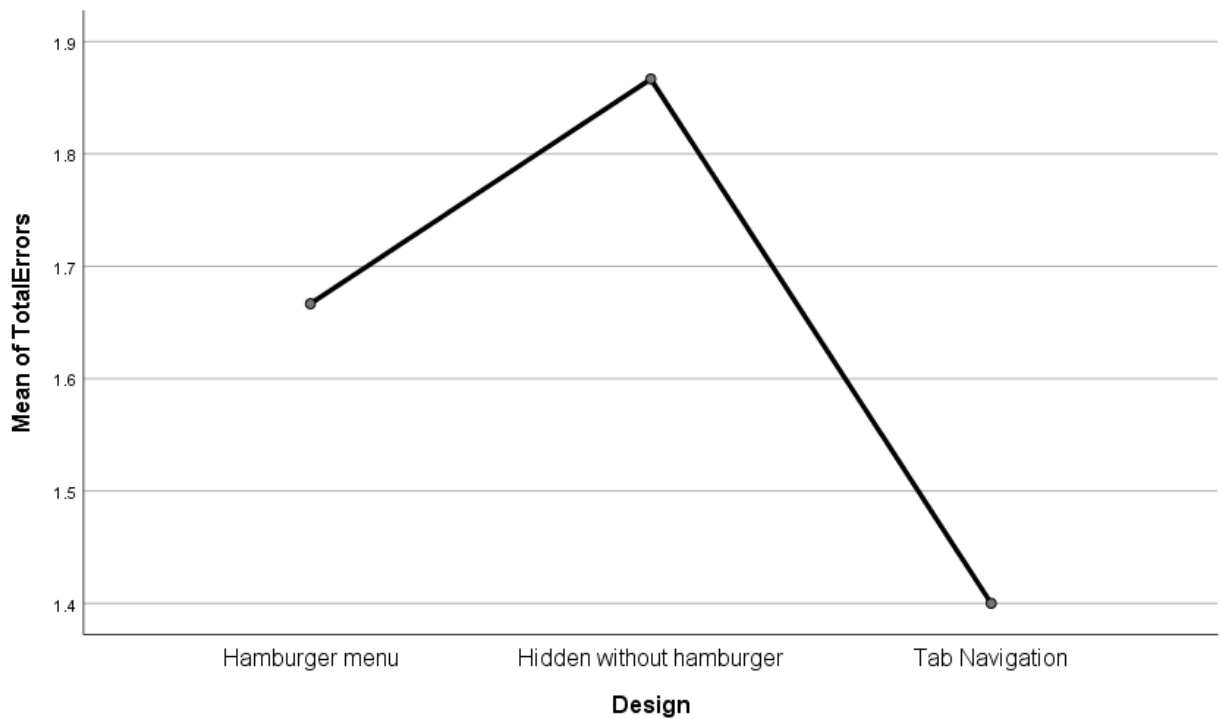
<div align="center">Figure 18: Task three errors- Means Plot</div>

The average error for task four shows that tab navigation is less erroneous with error of 1.4 followed by hamburger menu design with error rate of 1.6. The hidden navigation design without hamburger icon has an average of more errors (1.9).

6.2.2.2.4 Errors in Task Four

6.2.2.2.4.1   Descriptive Statistics

Menu design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Hamburger menu	15	1.67	1.175	0.303	1.02	2.32	0	4
Hidden without hamburger	15	1.80	1.373	0.355	1.04	2.56	0	5
Tab Navigation	15	1.40	0.828	0.214	0.94	1.86	0	3
Total	45	1.62	1.134	0.169	1.28	1.96	0	5

Figure 19: Task four errors- Descriptive Statistics

The table shows that the mean errors occurred while completing task four for menu design with hidden navigation without hamburger icon appears to slightly higher than the remaining two designs, with a difference of 0.40 errors with tab navigation and 0.13 errors with hamburger menu design.

6.2.2.2.4.2   Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
1.055	2	42	0.357

Table 32: Task four errors- test for homogeneity of variances

The test for homogeneity of variance for errors occurred while performing task four using Levene statistics shows that the significance is 0.357, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.2.2.4.3   ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.244	2	.622	.472	.627
Within Groups	55.333	42	1.317		
Total	56.578	44			

Table 33: Task four errors- Anova Statistics

The ANOVA statistics from task 4 shows that there is a mean difference in total errors occurred while completing task 4 across different menu designs. It is reported as $F(2,42)=.472$ The significance value is 0.627 which is more than 0.05. Hence no significant difference in total number of errors while performing task one is found.

6.2.2.2.4.4   Means Plot
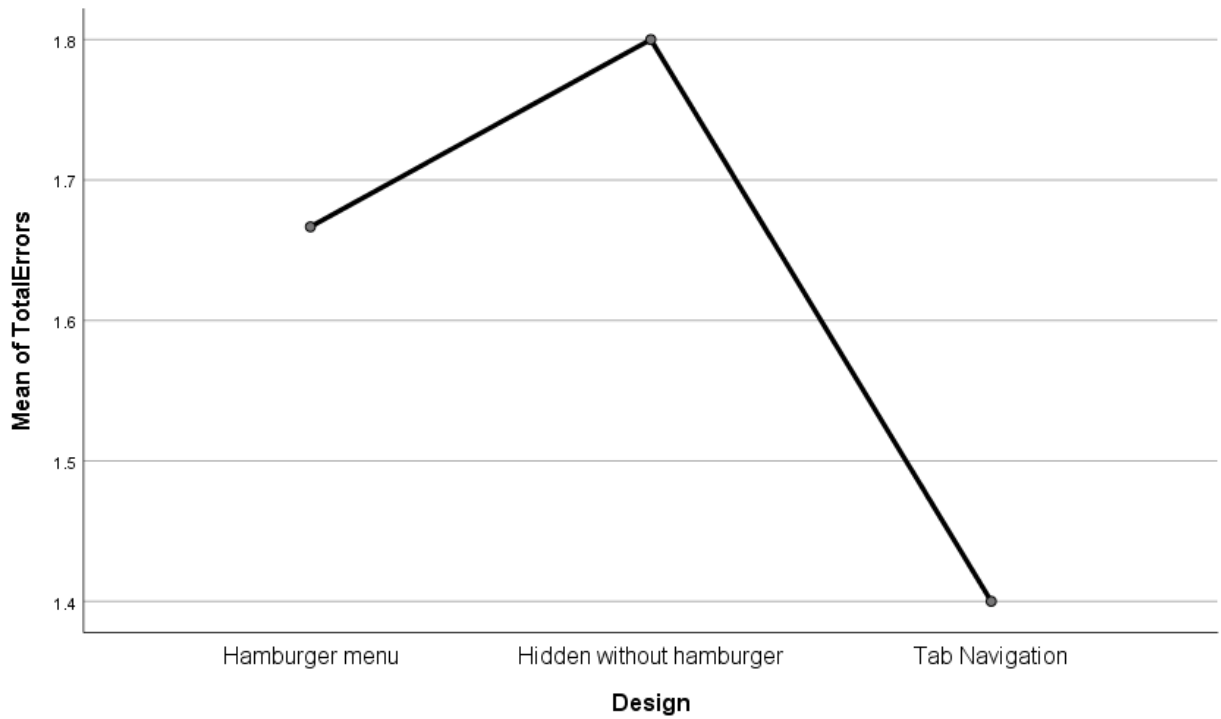
Figure 20: Task four errors- Means Plot.

For task four, tab navigation has average of less errors (1.4 errors), followed by hamburger menu design (1.6 errors) and hidden navigation without hamburger design(1.8 errors).

6.2.2.2.5 Errors in Task Five

6.2.2.2.5.1   Descriptive Statistics

Menu design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		

Hamburger menu	15	1.47	0.915	0.236	0.96	1.97	0	3
Hidden without hamburger	15	1.60	0.986	0.254	1.05	2.15	0	3
Tab Navigation	15	1.40	0.828	0.214	0.94	1.86	0	3
Total	45	1.49	0.895	0.133	1.22	1.76	0	3

Table 34: Task Five errors- Descriptive Statistics

The table shows that the mean errors occurred while completing task four for menu design with hidden navigation without hamburger icon appears to slightly higher than the remaining two designs, with a difference of 0.20 errors with tab navigation and 0.13 errors with hamburger menu design.

6.2.2.2.5.2   Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
.322	2	42	0.726

Table 35: Task five errors- test for homogeneity of variances

The test for homogeneity of variance for errors occurred while performing task five using Levene statistics shows that the significance is 0.726, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.2.2.5.3   ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	.311	2	.156	.187	.830
Within Groups	34.933	42	1.832		
Total	35.244	44			

Table 36: Task five errors- Anova Statistics

The ANOVA statistics from task 5 shows that there is a mean difference in total errors occurred while completing task 5 across different menu designs. It is reported as $F_{(2,42)}=.187$ The significance value is 0.830 which is more than 0.05. Hence no significant difference in total number of errors while performing task one is found.

6.2.2.2.5.4   Means Plot
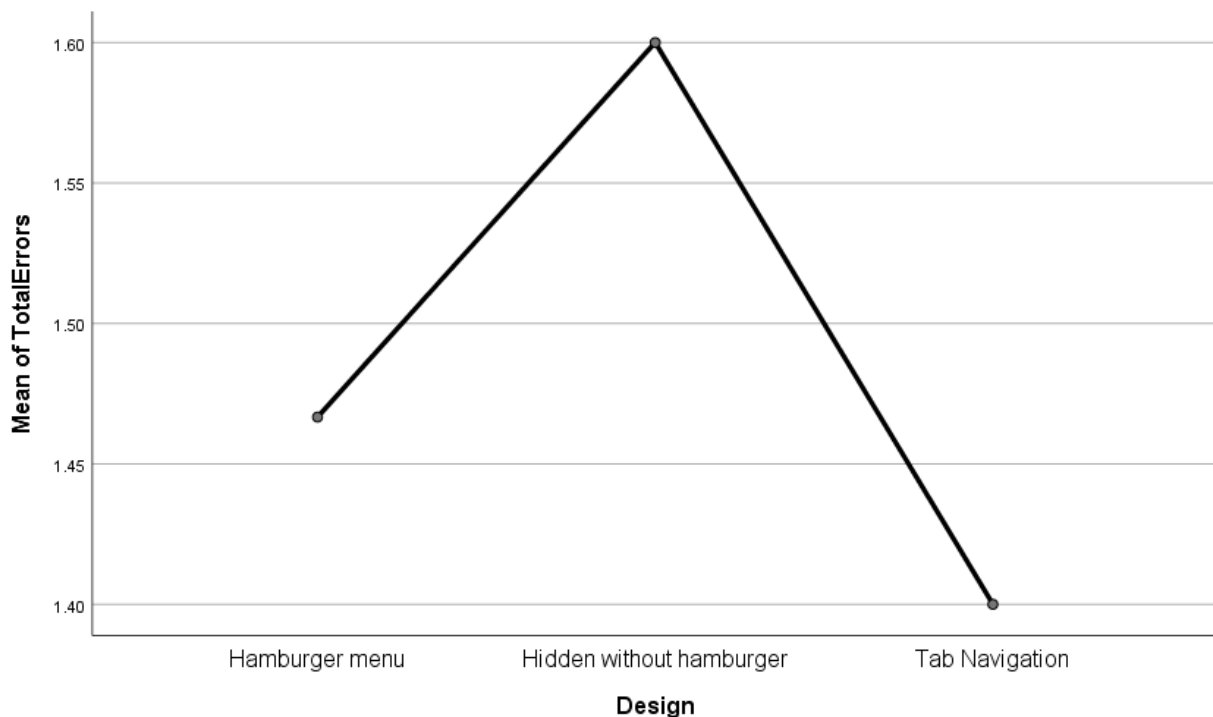
Figure 21: Task five errors- Means Plot

For task five, tab navigation design has a smaller number of average errors with 1.4 followed by hamburger menu with 1.45 errors, and hidden navigation without hamburger menu design with 1.6 errors.

6.2.2.2.6 Errors in Task Six

6.2.2.2.6.1   Descriptive Statistics

Menu design	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Hamburger menu	15	3.47	1.685	0.435	2.53	4.40	1	7
Hidden without hamburger	15	3.13	1.407	0.363	2.35	3.91	0	5
Tab Navigation	15	1.93	1.280	0.330	1.22	2.64	0	4
Total	45	2.84	1.580	0.236	2.37	3.32	0	7

Table 37: Task Six errors- Descriptive Statistics

The table shows that the mean errors occurred while completing task six for tab navigation appears lower than the remaining two menu designs by around 1.5 errors.

6.2.2.2.6.2 Test for homogeneity of variances:

Levene Statistic	df1	df2	Sig.
.708	2	42	0.498

Table 38: Task Six Errors- test for homogeneity of variances

The test for homogeneity of variance for errors occurred while performing task six using Levene statistics shows that the significance is 0.498, which is higher than 0.05, and hence the data does not violate the assumption of homogeneity of variance.

6.2.2.2.6.3 ANOVA Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19.511	2	9.756	4.532	.017
Within Groups	90.400	42	2.152		
Total	109.911	44			

Table 39: Task Six errors- Anova Statistics

The ANOVA statistics from task 6 shows that there is a mean difference in total errors occurred while completing task 6 across different menu designs. It is reported as $F(2,42)=4.532$. The significance value is 0.017 which is less than 0.05. Hence, some significance difference is felt in the number of errors occurred while completing task 6.

To find out the significant difference, a post hoc analysis is carried out.

Dependent Variable:	Total Errors						
(I) Design			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Hamburger menu	Hidden without hamburger	0.333	0.536	0.809	-0.97	1.63
		Tab Navigation	1.533*	0.536	0.018	0.23	2.83
	Hidden without hamburger	Hamburger menu	-0.333	0.536	0.809	-1.63	0.97
		Tab Navigation	1.200	0.536	0.076	-0.10	2.50
	Tab Navigation	Hamburger menu	-1.533*	0.536	0.018	-2.83	-0.23
		Hidden without hamburger	-1.200	0.536	0.076	-2.50	0.10
Games-Howell	Hamburger menu	Hidden without hamburger	0.333	0.567	0.828	-1.07	1.74

		Tab Navigation	1.533*	0.546	0.024	0.18	2.89
	Hidden without hamburger	Hamburger menu	-0.333	0.567	0.828	-1.74	1.07
		Tab Navigation	1.200	0.491	0.054	-0.02	2.42
	Tab Navigation	Hamburger menu	-1.533*	0.546	0.024	-2.89	-0.18
		Hidden without hamburger	-1.200	0.491	0.054	-2.42	0.02
*. The mean difference is significant at the 0.05 level.						

Table 40: Task Six errors- Post hoc analysis.

Considering the number of errors, the tab navigation design is statistically significant with hidden navigation designs with hamburger icon. The design with hidden navigation and hamburger icon has an average of 1.533 more errors than the design with tab navigation, while performing task six.

6.2.2.2.6.4 Means Plot
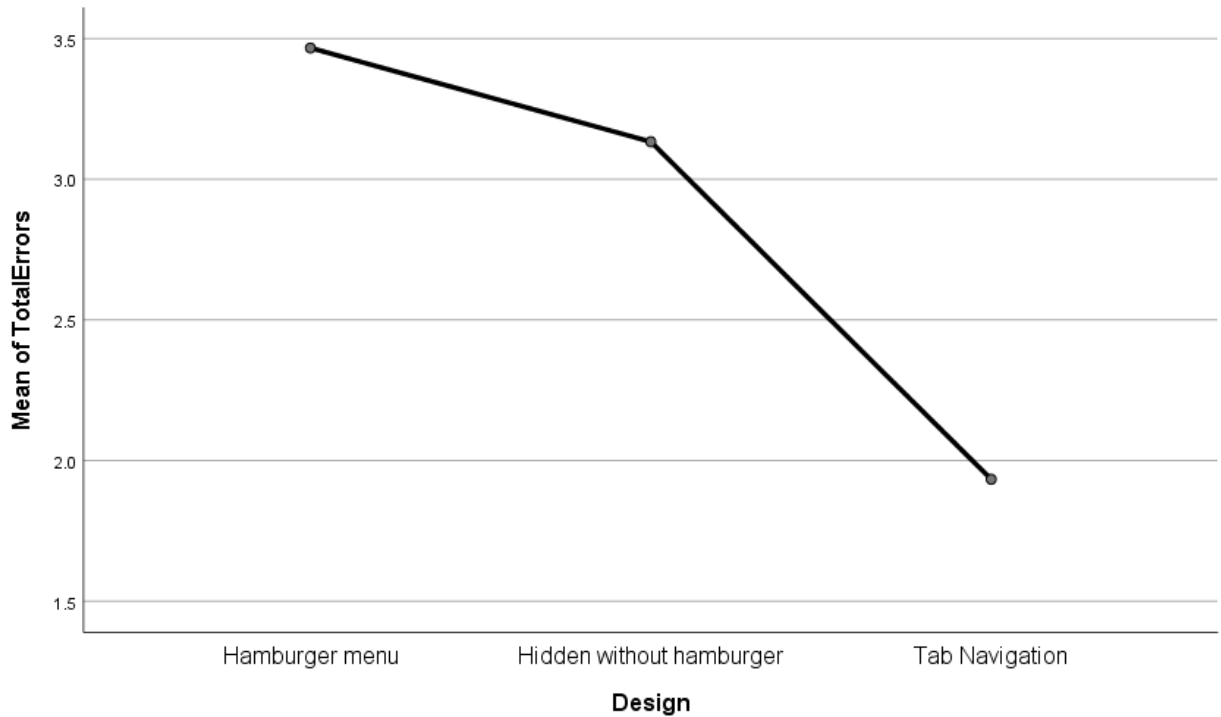
Figure 22: Task six errors- Means Plot

The means plot shows that tab navigation design has the lowest number of average errors with 2 errors and hamburger menu design has highest number of average errors with 3.5 errors, for task six. The menu design without hamburger icon and hidden navigation has an average of 3 errors for this task.

6.2.3 Participants responses towards experimental conditions

6.2.1.6   User interface

Statement 1: Text is easy to read.

Descriptive Statistics

The normality test of the responses from the participants for easiness of text to read shows that the data is normally distributed with p value of 0.50 for hamburger menu design, 0.82 for hidden navigation design without hamburger icon and 0.63 for tab navigation design. The Levene statistics also shows significance value of .820, which is greater than 0.05 and hence it does not violate the assumption homogeneity of variance. The value of significance using one-way Anova is 0.902.

The significance value from one-way Anova shows that (p= .902)>0.05 and hence no significant difference is felt among the three menu designs regarding the easiness of text to read. (See Appendix E)

Statement 2: The design is simple.

Descriptive Statistics

The normality test of the responses from the participants for simplicity of design to read shows that the data is normally distributed with p value of 0.50 for hamburger menu design, 0.63 for hidden navigation design without hamburger icon and 0.50 for tab navigation design. The Levene statistics also shows significance value of .955, which is greater than 0.05 and hence it does not violate the assumption homogeneity of variance. The value of significance using one-way Anova is 0.919.

The significance value from one-way Anova shows that (p= .919) >0.05 and hence no significant difference is felt among the three menu designs regarding the simplicity of design. (See Appendix E)

Statement 3: The color is well balanced and visually pleasing.

Descriptive Statistics

The normality test show that the significance value is 0.63, 0.50 and 0.56 for hamburger design, hidden navigation without hamburger icon and tab navigation design, respectively.

The Levene statistics shows significance value of .704, which is greater than 0.05 and hence it does not violate the assumption homogeneity of variance. The value of p is 0.906>0.05 from one-way Anova test. Hence, statistically no significant difference is felt between the three menu designs regarding the statement. (See Appendix E)

6.2.1.7   Usability of the navigation

Statement 4: Navigation Menu was easy to discover.

Descriptive Statistics

The normality test show that the significance value is 0.61, 0.63 and 0.50 for hamburger design, hidden navigation without hamburger icon and tab navigation design respectively.

The Levene statistics shows significance value of 0.752, which is greater than 0.05 and hence it does not violate the assumption homogeneity of variance. The significance value using one-way Anova is 0.618. Hence, statistically no significant difference is felt between the three menu designs regarding the statement. (See Appendix E)
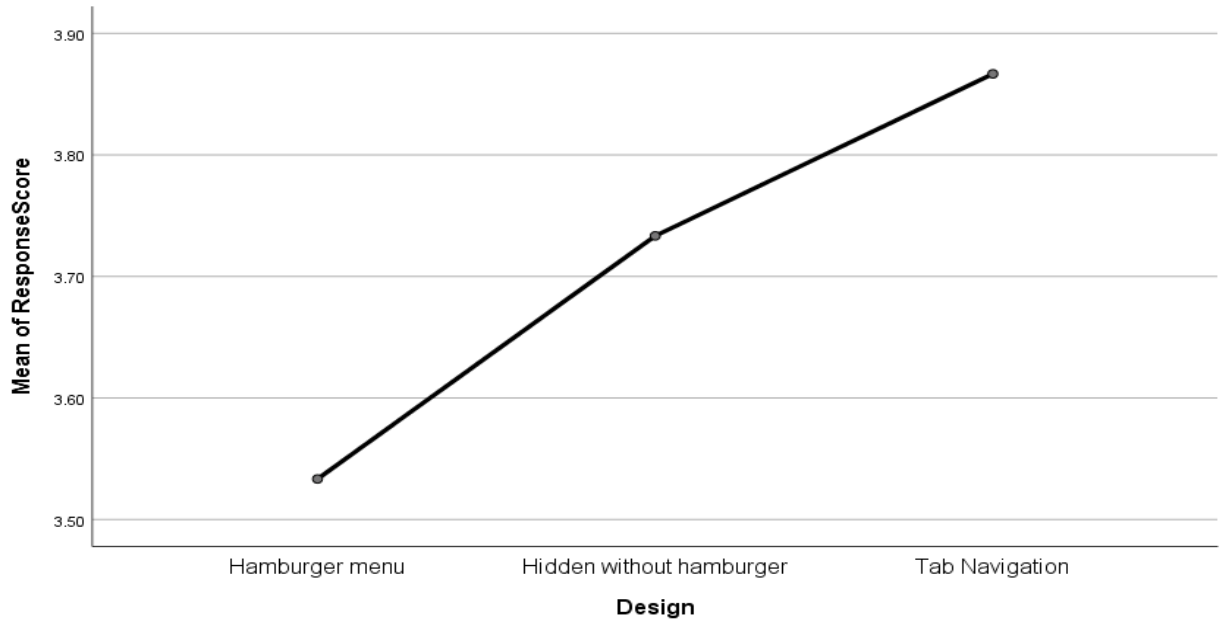
Figure 23: Response on discoverability of navigation- Means Plot

The means plot shows that the score is less for design with hamburger menu and is more for tab navigation design.

Statement 5: It was easy to locate the items I was looking for.

Descriptive Statistics

The normality test show that the significance value is 0.70, 0.52 and 0.56 for hamburger design, hidden navigation without hamburger icon and tab navigation design respectively.

The Levene statistics shows significance value of 0.665, which is greater than 0.05 and hence it does not violate the assumption homogeneity of variance. The significance value using one-way Anova is 0.929. Hence, statistically no significant difference is felt between the three menu designs regarding the statement. (See Appendix E)
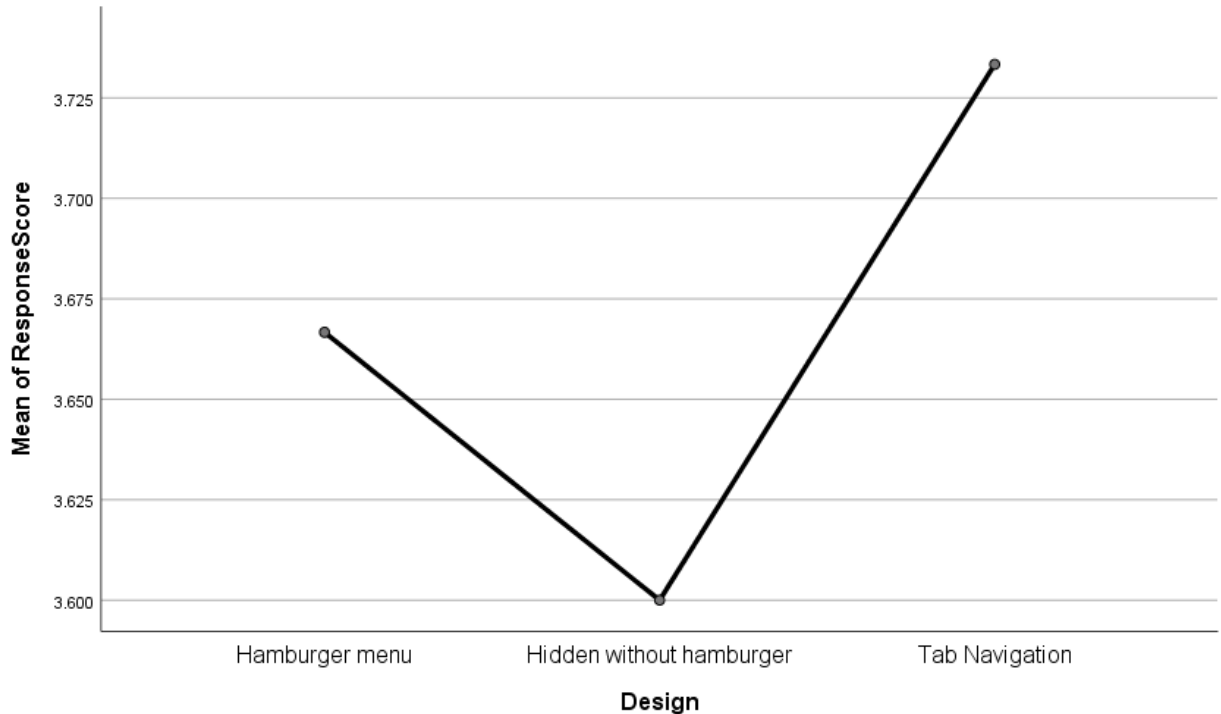
Figure 24: Response on locating items - Means Plot

The means plot shows that the score is less for design with hidden navigation without hamburger menu and is more for tab navigation design.

Statement 6: I prefer this kind of navigation in my smartphone as well.

Descriptive Statistics

The normality test of the responses from the participants for preference of design on smartphones shows that the data is normally distributed with p value of 0.64 for hamburger menu design, 0.52 for hidden navigation design without hamburger icon and 0.52 for tab navigation design. The Levene statistics also shows significance value of .421, which is greater than 0.05 and hence it does not violate the assumption homogeneity of variance. The significance value from one-way Anova shows that (p= .761) >0.05 and hence no significant difference is felt among the three menu designs regarding the simplicity of design. (See Appendix E)
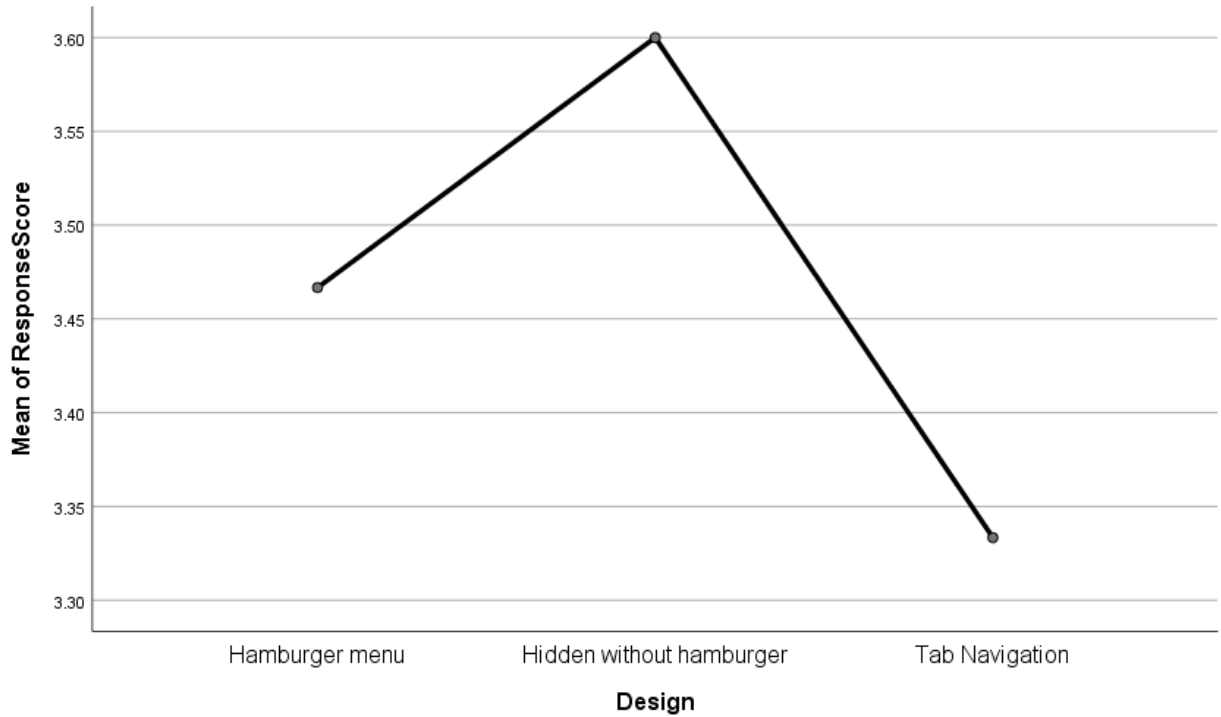
Figure 25: Response on preference on mobile phone - Means Plot

The means plot shows that the score for preference on mobile is higher for hidden navigation without hamburger icon and lower for tab navigation design.

Statement 7: It is easy to go deeper into the website with this menu.

Descriptive Statistics

The normality test of the responses from the participants for preference of design on smartphones shows that the data is normally distributed with p value of 0.64 for hamburger menu design, 0.64 for hidden navigation design without hamburger icon and 0.52 for tab navigation design. The Levene statistics also shows significance value of .411, which is greater than 0.05 and hence it does not violate the assumption homogeneity of variance. The significance value from one-way Anova shows that (p= .913) >0.05 and hence no significant difference is felt among the three menu designs regarding the statement. (See Appendix E)
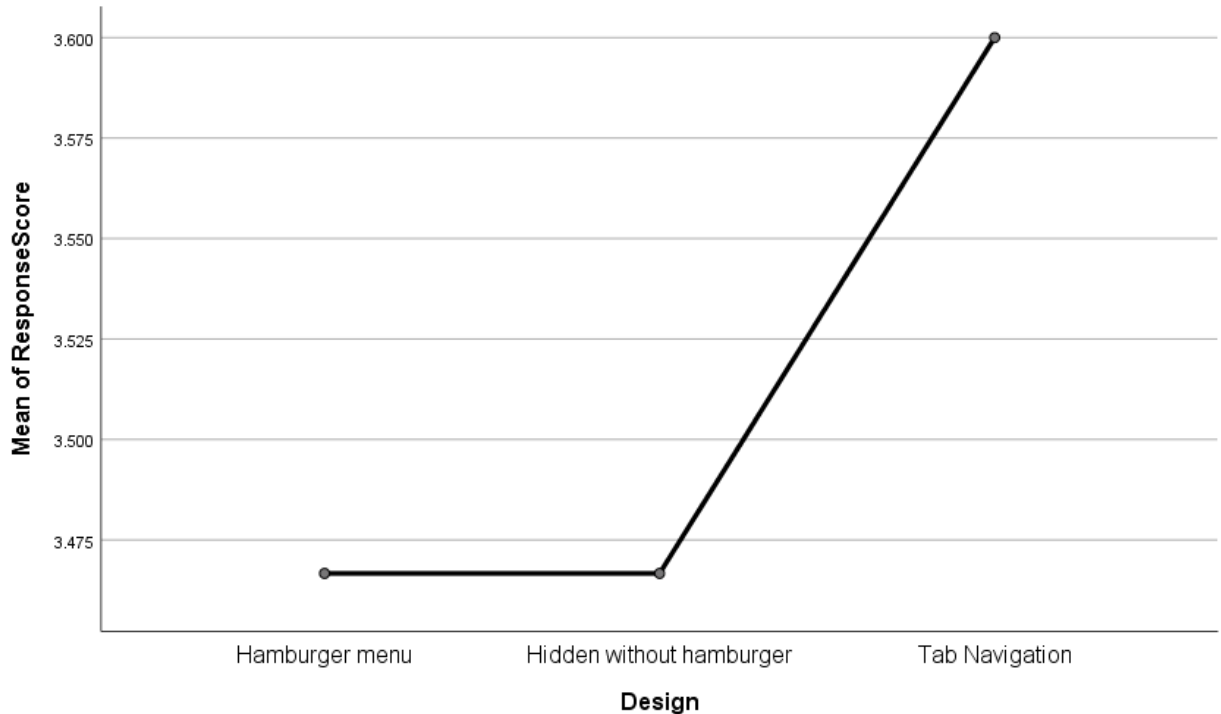
Figure 26: Response on easiness to go deeper into website- Means plot

The means plot shows that the score is higher for tab navigation design than remaining two.

Statement 8: I found navigation design pleasing while performing task.

Descriptive Statistics

The normality test show that the significance value is 0.52, 0.52 and 0.50 for hamburger design, hidden navigation without hamburger icon and tab navigation design, respectively. The Levene statistics also shows significance value of .485, which is greater than 0.05 and hence it does not violate the assumption homogeneity of variance. The significance value from one-way Anova shows that (p= .720) >0.05 and hence no significant difference is felt among the three menu designs regarding the statement. ([See Appendix E](#))
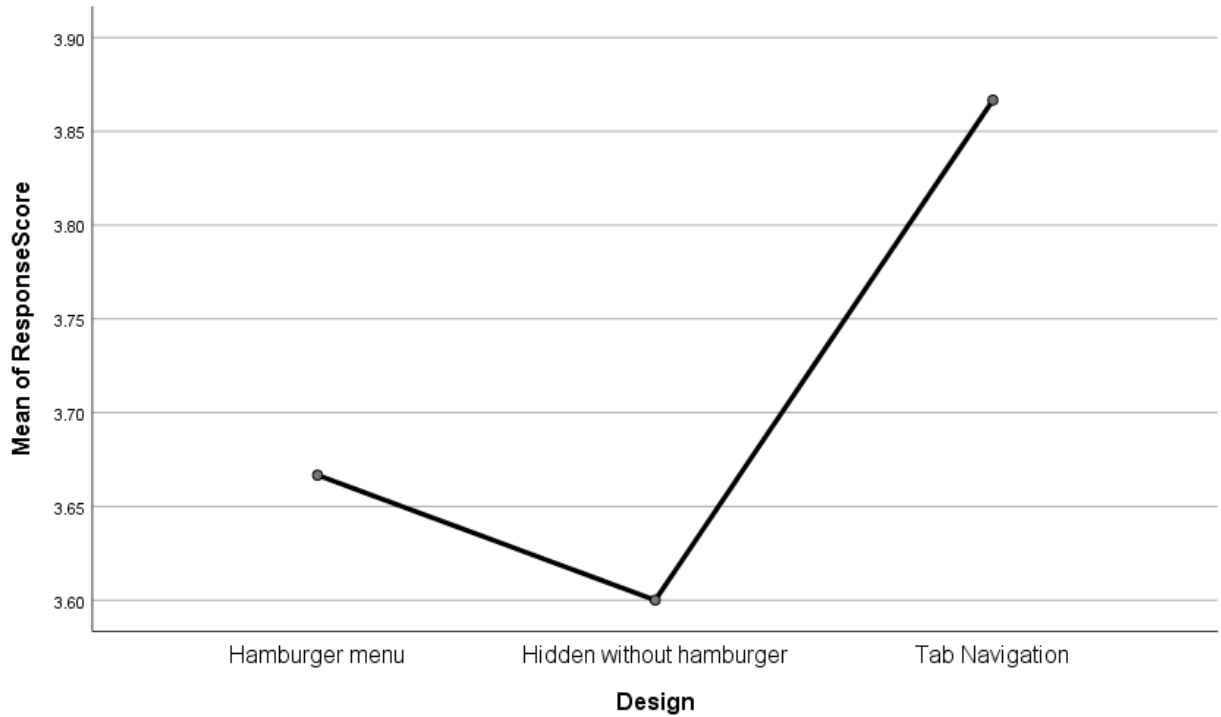
Figure 27: Response on pleasantness while using navigation- Means Plot

The means plot however shows that the average mean score is higher for tab navigation design than remaining two regarding the statement.

6.2.1.8   Tasks

Statement Nine: The tasks were easy to complete.

Descriptive Statistics

The normality test for score for the statement regarding easiness of tasks show that the significance value for easiness to complete is 0.56, 0.56 and 0.50 for hidden navigation with hamburger menu, hidden navigation without hamburger icon and tab navigation, respectively. The initial scores were transformed using arithmetic square root in in Spss to achieve normality. The levene statistics based on mean show that the significance value is .952, which shows no violation of assumption of homogeneity. The significance value from one-way Anova shows that it is .979>0.05. Hence, no significant difference is seen. The means plot however show that although the average score for tab navigation design is higher than the rest of hidden navigation pattern designs. (See Appendix E)
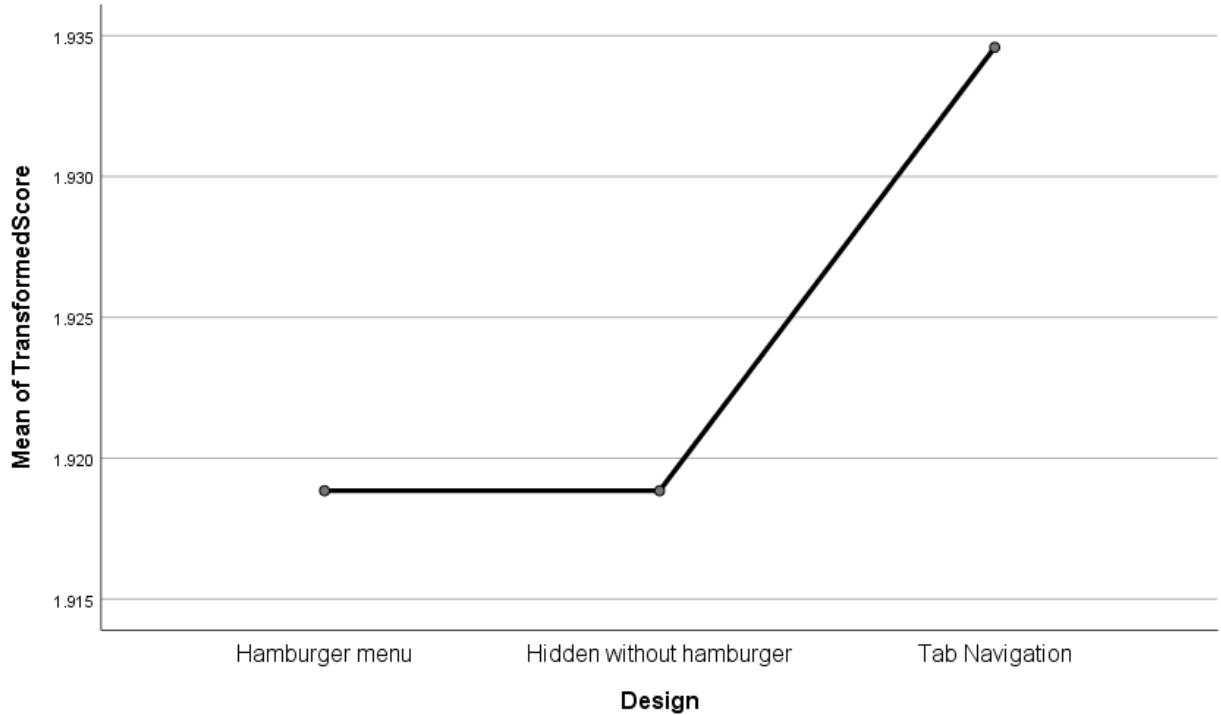
Figure 28:Response on easiness of tasks- Means Plot.

Statement Ten: The tasks were interesting.

The normality test for score of interestingness of tasks showed that the data is not normal for further tests. However, considering the robustness of independent one-way Anova test, further tests were also carried out to see if statistically significant difference is seen between the navigation designs regarding the statement. The further tests did not show any significant difference as well. The means plot show that the tasks were interesting for all the menu designs with an approximate of average score of 4 for both hidden navigations. The average score for tab navigation is slightly higher. (See Appendix E)
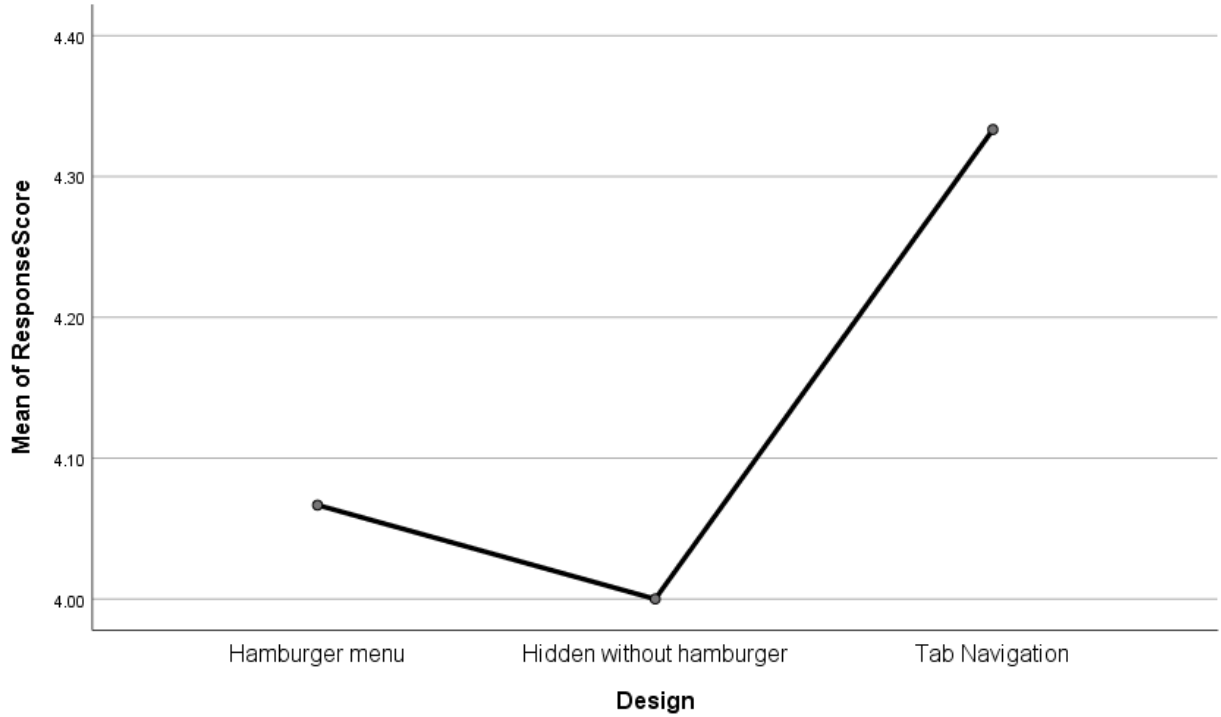
Figure 29:Response on interestingness of tasks- Means Plot

Statement Eleven: The tasks were easy to understand and well explained.

The score regarding the easiness and understandability of tasks show that they do not meet the criteria of parametric data. One-way Anova analysis was carried out for responses regarding the statement too, with no significant difference found. The means plot shows that the responses from tab navigation design had higher score than rest of the two designs. (See Appendix E)

Figure 30:Response on understandability of tasks- Means Plot

7. Discussions

The purpose of the study was to understand different navigation designs and their usability, particularly comparing the hidden navigation pattern in menu design with two other designs and finding out the usability of the design. This was done by conducting usability evaluation experiment with 45 participants using between group experiment (15 participants for each navigation design). Different tasks were formulated with variance in difficulties with an aim to address possible scenarios of use in any navigation design. The statistical analysis indicates that there is faster task completion time and lower errors with tab navigation design as compared to hamburger navigation design and hidden navigation design without hamburger icon.

This chapter includes a discussion on the key findings of the literature related to usability of hidden navigation pattern with hamburger icon, a summary of the analysis of results of the experiment, and what implications could be valuable for designers, user interface experts and developers. Also included in this chapter is discussion on the areas of limitations of study, a summary of the study and areas of future research.

7.1 Summary of analysis of results

7.1.1 Total task completion time

The statistical significance value for total time required for participants to perform the tasks varied according to tasks and menu designs. Two of the devised hypotheses: hypothesis1 and hypothesis 2 depend on total task completion time.

Regarding hypothesis 1, the null hypothesis (h0) -" There will be no difference in the time required for participants to discover navigation menu for all the designs", is rejected since statistically there is some significant difference in the total time required for users to locate the main navigation menu across the three different menu designs. Participants took less time to discover the main navigation with tab navigation design. A statistically significant difference is found between tab navigation design and remaining two hidden navigation design patterns.

Regarding hypothesis 2, the null hypothesis (h0)- "There will be no significant difference in the time required for participants to complete the tasks for all the navigation menu

designs", is partially accepted since no statistical significance is observed in total time taken to complete tasks 2, 3,4 and 5, across all navigation designs. However, for task 6, a statistically significant difference is observed which rejects the null hypothesis. Task 6 is relatively complex task as compared to the remaining tasks since the task involved finding difference in price of items located in higher order menu. Participants took an average of 33 seconds lesser while performing task 6 with tab navigation design than with hidden navigation design without hamburger icon. In the same way, the hamburger menu design was slower than tab navigation design to complete task6, with a difference of 36 seconds. There is no significant difference observed in total task completion time for any tasks, between the two hidden navigation designs.

7.1.2 Total Number of Errors

Hypothesis 3 is related to the total number of errors made while performing the tasks. The null hypothesis(h0) – "There will be no difference in number of errors made by participants for all the menu designs", is partially rejected since a significant difference was observed while comparing total number of errors across different menu designs for task 6. The post hoc analysis using Tukey and Game's Howell shows that participants made an average of 1.5 errors more for hidden navigation design with hamburger icon as compared to tab navigation design. However, no significant difference is observed in total errors made between two hidden navigation design patterns.

7.1.3 Participants Responses towards experimental conditions

Various questions were formulated to get opinions of participants on the experimental conditions after the experiments in terms of Likert scale. The questions were related to user interface, the design of the tasks, the usability of navigation and satisfaction level of users towards the experimental prototypes. The Likert scale score for tab navigation design with mega-dropdown menus is higher for the statements: easiness to go deeper into menu, easiness to locate items inside the website and discoverability of the navigation menu itself within the website. Regarding the null hypothesis for hypothesis four, h0 - "Participants will be satisfied equally for all the menu designs.", is rejected since the satisfaction level of users towards the navigation design is higher for tab navigation design than the remaining two hidden navigation design patterns. The

responses indicate that tab navigation design complies more with the universal design principles of "perceptible information" and "simple and intuitive".

7.2 Comparison with Previous Research

The previous literatures regarding the total task completion time using different menu designs indicate that the users consume more time to perform tasks while using hidden navigation pattern as compared to other navigation designs. Study from (Nesler, 2016) shows that the task completion time is higher for hidden navigation, resulting in more information cost. Casadei(2017) also had similar findings with the hidden navigation pattern, resulting in a higher number of mouse clicks and invisibility of menu items at first glance. The current study also shows the similar results: hidden navigation designs, with or without hamburger icon, are more time consuming and have higher number of errors than tab navigation design. It also indicates that the order of presentation of menu also impacts the user's performance. The tasks involving selection of items located in higher order menu had more errors, consuming more time.

A new menu design replacing stacked lines with word "menu" as a substitute to hamburger icon, breaking the general convention of use of icon in hidden navigation pattern was introduced in this study. One of the crucial findings from (Santa-Maria et al., 2008) was that the disorientation and hinderance of performance for novice design is short lived and does not have long term effect. Although there was some mathematical difference in total task completion time and number of errors between two hidden navigation patterns, no statistically significant difference was found between the two menu designs. In that context, this study agrees with the previous finding regarding short-lived disorientation from new design.

Regarding the study of icon based menus, the study from (Schröder & Ziefle, 2008) shows that 39 out of 40 participants were able to perform task with icon-based menu. Similar pattern is found in this study since all the participants assigned for experiment with icon-based menu design using hamburger icon were able to complete all the tasks, likely due to their experience on the use of similar websites and technology. The users were familiar with the hamburger icon and were aware about what those three stacked lines represent.

Most of the previous research relating to menu designs were inclined towards positioning of menu, and very little has been done to study hidden navigation pattern. Among them, most of the studies focus on mobile applications. Until recently, there has been little interest in usability and universal design of hidden navigation patterns in websites for desktop users. This study also aims to add an additional input to the study of universal design and usability of navigation design patterns in websites by collecting opinions on factors of usability connecting principles of universal design.

This study puts forward an approach of introducing a word "Menu" instead of hamburger icon as an alternative to the hidden navigation patterns using icons in websites. This approach could improve usability, while making the design clean, allowing users to view the navigation options whenever required without prior knowledge about the hamburger icon used in navigation.

7.3 Problems and Limitations

Based on results of total completion time, a large difference was observed for task 6, with tab navigation performing better than the hidden navigation design patterns. The future experiments should concentrate more on complex tasks to check if a significant difference in total task completion time and errors exists between the design patterns.

The responses of post experiment questions collected through Likert scale scores were 4 or 5 out of 5. This might have occurred after participants knew that the websites used for the experiment are prototypes developed by the observer. A necessity of open-ended questions was felt for post-experiment feedback to get more detailed answers. The questionnaire in its scaled form did not allow for detailed analysis of answers and further probing in depth could not be done.

The use of steps recorder for recording the participant's performance required a lot of observation. A lot of time was consumed while transferring the data from the recorder output, which consumed a lot of time. A better approach like use of automated tools than screen recording could have made the process much faster.

The use of windows operating system only while conducting experiments is one of the limitations. Although the participants were familiar about the operating system, the results might defer if system preferred by the participants for daily use is used.

One of the major aims of this study was to answer whether the hidden navigation design pattern violates the principles of universal design or not. Post experiment responses, task completion time and errors made, were taken as parameters to evaluate the universal design of the navigation design patterns. Still a necessity of tasks which directly connect universal design would answer the related questions more effectively. The selection of universal design experts as participants would be better to find out more on the seriousness of violations of universal design principles when hidden navigation design patterns are used.

8. Conclusion

The research aimed to identify whether hidden navigation design pattern impacts performance of user and usability of the website, as compared to other navigation designs. Based on a quantitative analysis of total task completion time and errors, and post experiment opinions on satisfaction level, it can be concluded that the efficiency of hidden navigation pattern is less as compared to tab navigation design, while completing tasks of similar nature.

The results show that it takes more time to locate the navigation menu when hidden navigation pattern is adopted in websites. It also shows that the users are less satisfied with such design patterns. Although statistically no significant difference is found regarding total task completion time for few tasks across all navigation designs in this study, the tests were significantly in favor of tab navigation for complex task. Task 6 was complicated than other 5 tasks. A difference of 33 seconds was found between tab navigation and two of the hidden navigation pattern designs. It indicates that hamburger menus are worse for complex tasks, but undoubtedly more work is required since it is difficult to be categorical based on one difficult task.

The hamburger icon itself as a representative of menu, did not have much impact on user's performance. The recruited participants were able to complete the tasks without any complication regarding understandability of hamburger icon. Introducing a new design type replacing 'hamburger' icon with "Menu" did not have much impact on the user performance and usability of navigation. There was not a significant difference in the total task completion time and errors made, as well as score levels regarding the navigation design. It also indicates that the icon itself might not be the issue for experienced users.

In addition, this research tries to find if the universal design principles of 'simple and intuitive to use' and 'perceptible information', are adopted by the navigation designs. The responses of participants regarding satisfaction level, discoverability of items, easiness to go deeper into website and easiness to locate items, suggest that the hidden navigation patterns might be unsatisfying concerning the principle of 'Perceptible Information'. The possibility of cognitive overload cannot be denied when the menu

96

exists in higher level of hierarchy. It might raise a question of whether inclusiveness of diverse users is taken into consideration by the navigation design. Likewise, considering the factors of usability like efficiency, errors, and satisfaction levels according to Nielsen (2012), it is found that hidden navigation design pattern is less usable compared to tab navigation design.

The overall results of the study suggest that hidden navigation patterns with or without a representative icon, can somehow impact usability of the websites if the desired menu is in higher level of hierarchy in content rich applications. The research relies on quantitative data analysis, conducting experiment using website prototypes, on users who are already familiar with the navigation designs. It would be interesting to see the performance of novice users on the hidden navigation designs with hamburger icon, using different platform - preferably mobile, using more scientific tools of measurement.

8.1 Reflections

It was interesting as well as challenging to conduct the research. From designing the prototype to analyzing the data was a good journey of the study, with a lot of learnings. It was difficult to find the participants at first, but a sense of accomplishment was there when the experiment finished with 15 participants in each group. Recruiting the participants, arranging meetings, and conducting experiment was all part of a good learning process.

The hidden navigation pattern with "Menu" as substitute of hamburger icon did not have much difference in performance as expected by the author. Many people seem to be familiar with hamburger icon.

One of the reasons to select Likert scale as post-experiment questions to collect feedback on usability of navigation design was to make the experiment as short as possible. The necessity of open-ended questions was felt to collect opinions as it did not take much time to finish the whole process.

Few of the tasks were repetitive in nature. The primary aim to design them was to see the impact of learnability on performance within a particular design pattern. But this could not be studied in detail due to lack of further questions on learnability.

One of the things the author would do differently is find more diverse open-ended questions and collect descriptive opinions of experts regarding navigability and universal design of user interface.

8.2 Recommendations for future work

More research on usability of websites and different navigation design patterns is suggested for future. The results from this study provide some interesting opportunities to investigate on possible best practices and alternatives to hidden navigation patterns to improve usability. Recruiting universal design and usability experts would add greater depth in the study to understand whether the designs comply with the standards or not.

The context of the websites used for the experiment is an online shopping store assuming that a typical website would have a similar design pattern. The tasks designed for this study were categorized from simple to complex, with simple being less time consuming and complex being more time consuming. Having more complex tasks gave a significant result and the pattern continued for all the menu designs. One of the suggestions for similar studies in future would be to incorporate variations in tasks and have more complex tasks.

The participants selected for the experiment were already familiar with different website menu designs used in the experiment which might have resulted in less significance in overall result. It cannot be neglected that there is a probability of getting more significant results if the users are novice to the menu designs. Considering the factors like experience with internet and technology while conducting the research can provide a good comparison.

The satisfaction level of using any website design might vary according to user's experience level and opinion. The study had several post-experiment questionnaires to get opinions regarding the satisfaction level from the navigation designs and their usability. The parameters for satisfaction might differ from person to person. Open ended subjective questionnaires are highly recommended to get more comprehensive feedback for future studies.

The devices used during the evaluation process of the study were all windows based operating systems provided by the researcher. The possibility of inaccuracy cannot be

denied due to unfamiliar user environment. Testing with user's preferred environment would be a good step for future works, for research of similar nature.

The study aimed to extend the knowledge on different navigation designs on websites and emphasizes to avoid hidden navigation patterns for future designers, user interface experts and developers whenever possible, if not, to have an option to search the items easily so that users can satisfy their information needs quickly and conveniently. A further suggestion would be to get a better alternative for hidden navigation patterns to make navigation simple and easily accessible so that navigation designs would comply with the principles of universal design.

9. References

Abreu, L. (Producer). (2019, 03 01). Why and How to Avoid Hamburger Menus - Louie A. - Product Design. Retrieved from https://lmjabreu.com/post/why-and-how-to-avoid-hamburger-menus/

Adams, A., Lunt, P., & Cairns, P. (2008). A qualititative approach to HCI research.

Agrawal, R., & Venkatesh, V. (2002). Assessing a firm's web presence: a heuristic evaluation procedure for the measurement of usability. *Information systems research*, 168-186.

Armando J. Rotondi, J. S., Gretchen L. Haas, Michael B. Spring,Christine M. Litschge, Christina E. Newhill, Rohan Ganguli, and Carol M. Anderson. (2007). Designing Websites for Persons With Cognitive Deficits: Designand Usability of a Psychoeducational Intervention for Persons WithSevere Mental Illness. *Psychological Services*, 202.

Babich, N. (Producer). (2019, 03 05). Basic Patterns For Mobile Navigation: Pros And Cons — Smashing Magazine. *smashingmagazine*. Retrieved from https://www.smashingmagazine.com/2017/05/basic-patterns-mobile-navigation/

Berg, B. L., Lune, H., & Lune, H. (2004). *Qualitative research methods for the social sciences* (Vol. 5): Pearson Boston, MA.

Bernard, M. L. (2001). *Developing schemas for the location of common web objects.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting, Los Angeles, CA.

Brajnik, G. (2008). *Beyond conformance: the role of accessibility evaluation methods.* Paper presented at the International Conference on Web Information Systems Engineering, Beriln.

Budiu, R. (2018). Between-Subjects vs. Within-Subjects Study Design. In: Retrieved from Nn Group: https://www. nngroup. com/articles/between-within ….

Bulboaca, H. (Producer). (2019, 03 02). The Rise and Fall of Hamburger Menu-Horial Bulboaca-medium. *Medium*. Retrieved from https://medium.com/@horiab/the-rise-and-fall-of-the-hamburger-menu-d4bc8b29d863

Burrell, A., & Sodan, A. C. (2006). *Web Interface Navigation Design: Which Style of Navigation-Link Menus Do Users Prefer?* Paper presented at the 22nd International Conference on Data Engineering Workshops (ICDEW'06), Atlanta, GA, USA, USA.

Cairns, P., & Cox, A. L. (2008). *Research methods for human-computer interaction* (Vol. 12): Cambridge University Press Cambridge.

Cappel, J. J., & Huang, Z. (2016). A Usability Analysis of Company Websites. *Journal of Computer Information Systems*, 117-123.

Cardello, J., & Whitenton, K. (Producer). (2014, 2 9). Killing off the global navigation: One trend to avoid. *Nielsen Norman Group*. Retrieved from https://www.nngroup.com/articles/killing-global-navigation-one-trend-avoid/

Carroll, J. M. (2003). *HCI models, theories, and frameworks: Toward a multidisciplinary science*: Elsevier.

Casadei, V., Granollers, T., Zaina, L. (2017). *Investigating accessibility issues of UI mobile design patterns in online communities: a virtual ethnographic study.* Paper presented at the Proceedings of the XVI Brazilian Symposium on Human Factors in Computing Systems New York.

Constantine, Lockwood, L. L. a., & AD, L. (2002). Instructive interaction: Making innovative interfaces self-teaching. *User Experience*.

Constantinos K. Coursaris, D. J. K. (2011). A Meta-Analytical Review of Empirical Mobile Usability Studies. *Journal of Usability Studies*, 117-171.

Coursaris, C. K., & Kim, D. J. (2011). A Meta-Analytical Review of Empirical Mobile Usability Studies. *Journal Of Usability Studies*, 117-171.

Damaceno, R. J. P., Braga, J. C., & Mena-Chalco, J. P. (2018). Mobile device accessibility for the visually impaired: problems mapping and recommendations. *Universal Access in the Information Society*, 421-435.

DeMatteo, D., Marczyk, G., & Festinger, D. (2005). *Essentials of research design and methodology*: john wiley & Sons, Inc.

DeWitt, A. J. (2010). Examining the order effect of website navigation menus with eye tracking. *Journal of Usability Studies*, 39-47.

Elkatawneh, H. (2016). Comparing Qualitative and Quantitative Approaches. *Available at SSRN 2742779*.

Fichter, D. a. W., Jeff. (2016). Emotional design, storytelling,'slippiness,'and understandable icons. *Online Searcher*, 74-76.

Frye, D., & Soloway, E. (1987). *Interface design: A neglected issue in educational software.* Paper presented at the ACM SIGCHI Bulletin.

Garczarek-Bąk, U. (2016). Trends in Website Development Based on the Chosen Functionalities in Qualitative Aspect. *Studia Oeconomica Posnaniensia*, 164-184.

Gay, G., & Li, C. Q. (2010). *AChecker: open, interactive, customizable, web accessibility checking.* Paper presented at the Proceedings of the 2010 International Cross Disciplinary Conference on Web Accessibility (W4A).

Geven, A., Sefelin, R., & Tscheligi, M. (2006). *Depth and breadth away from the desktop: the optimal information hierarchy for mobile use.* Paper presented at the Proceedings of the 8th conference on Human-computer interaction with mobile devices and services, New York.

Ghosh, D., & Vogt, A. (2012). *Outliers: An evaluation of methodologies.* Paper presented at the Joint statistical meetings.

Gittins, D. (1986). Icon-based human computer interaction. *International Journal of Man-Machine Studies*, 519-543.

Hasan, B. (2016). Perceived irritation in online shopping: The impact of website design characteristics. *Computers in Human Behavior*, 224-230.

Kacmar, C. J. a. C., Jane M. (1991). Assessing the usability of icons in user interfaces. *Behaviour and Information Technology*, 443-457.

Kalbach, J. a. B., Tim. (2003). Web page layout: A comparison between left-and right-justified site navigation menus. *Journal of Digital Information*.

Killing Off the Global Navigation: One Trend to Avoid | Nielsen Norman Group. (2014, 2 14). *Nielsen Norman Group*. Retrieved from https://www.nngroup.com/articles/killing-global-navigation-one-trend-avoid/

Kim, K., Proctor, R. W., & Salvendy,G. (2011). Comparison of 3D and 2D menus for cell phones. *Computers in Human Behavior*, 2056-2066.

Krug, S. (2014). *Don't Make Me Think Revisited: A Common Sense Approach to Web Usability* New Riders Pub.

Lazar, J., Feng, J. H., & Hochheiser, H. (2017). *Research methods in human-computer interaction*: Morgan Kaufmann.

Lee, S., & Koubek, R. J. (2010). The effects of usability and web design attributes on user preference for e-commerce web sites. *Computers in Industry, 61*(4), 329-341.

Lee, Y., & Kozar, K. A. (2012). Understanding of website usability: Specifying and measuring constructs and their relationships. *Decision Support Systems*, 450-463.

Leuthold, S. a. S., Peter and Bargas-Avila, Javier A and Tuch, Alexandre N and Opwis, Klaus. (2011). Vertical versus dynamic menus on the world wide web: Eye tracking study measuring the influence of menu design and task complexity on user performance and subjective preference. *Computers in human behavior*, 459-472.

Lopes, A. G. (2016). Using research methods in human computer interaction to design technology for resilience. *JISTEM-Journal of Information Systems and Technology Management, 13*(3), 363-388.

Mayers, A. (2013). *Introduction to statistics and SPSS in psychology*: Pearson Higher Ed.

Murano, D. P., & Lomas, T. J. (2015). Menu Positioning on Web Pages. Does it Matter? *International Journal of Advanced Computer Science and Applications*, 141-147.

Murano, P., & Khan, I. N. (2015). Pie Menus or Linear Menus, Which Is Better? *Journal of Emerging trends in Computing and Information Sciences*, 476-481.

Murano, P., & Lomas, T. J. (2015). Menu Positioning on Web Pages. Does it Matter?

Murano, P., & Sander, M. (2016). User interface menu design performance and user preferences: a review and ways forward. *International Journal of Advanced Computer Science and Applications, 7*(4), 355-361.

Neilsen, J. (2009). Mega menus work well for site navigation. *Tillgänglig: http://www. nngroup. com/articles/mega-menus-work-well*.

Nesler, D. (Producer). (2016, 2 25). To hamburger or not to hamburger – Digital Experience Design – Medium. *Medium*. Retrieved from https://medium.com/digital-experience-design/to-hamburger-or-not-to-hamburger-aad8b4a07576

Nielsen, J. (1994). 10 Usability Heuristics for User Interface Design. Retrieved from https://www.nngroup.com/articles/ten-usability-heuristics/

Nielsen, J. (Producer). (2012, 1 4). Usability 101: Introduction to Usability. *Nielsen Norman Group*. Retrieved from https://www.nngroup.com/articles/usability-101-introduction-to-usability/

NSD. (2019). Privacy Ombudsman for Research | NSD - Norsk senter for forskningsdata. Retrieved from https://nsd.no/nsd/english/pvo.html

One Hamburger, Hold the Menu | Cooper. (2014, 6 14). *Cooper*. Retrieved from https://www.cooper.com/journal/2017/8/hamburger_menu

Pernice, K. (2016). Ux prototypes: Low fidelity vs. high fidelity. *Nielsen Norman Group*.

Pernice, K., & Budiu, R. (Producer). (2016, 6 26). Hamburger Menus and Hidden Navigation Hurt UX Metrics. *nngroup*. Retrieved from https://www.nngroup.com/articles/hamburger-menus/

Persson, H., Åhman, H., Yngling, A. A., & Gulliksen, J. (2015). Universal design, inclusive design, accessible design, design for all: different concepts—one goal? On the concept of accessibility—historical, methodological and philosophical aspects. *Universal Access in the Information Society, 14*(4), 505-526.

Pilgrim, C. J. (2012). *Website Navigation Tools – A Decade of Design Trends 2002 to 2011.* Paper presented at the Proceedings of the Thirteenth Australasian User Interface Conference-Volume 126.

Rand, J. (Producer). (2019, 4 30). The Genius—and Potential Dangers—of the Hamburger Icon (Flyout Menu). Retrieved from https://vtldesign.com/web-strategy/website-design-development/hamburger-icon-flyout-menu-website-navigation/

Richard, T. (2013). Qualitative versus quantitative methods: Understanding why qualitative methods are superior for criminology and criminal justice.

Rohrer, C. (2014). When to use which user-experience research methods. *Nielsen Norman Group.*

Rosenfeld, L. a. M., Peter. (2002). *Information architecture for the world wide web*: O'Reilly Media, Inc.

Rosnow, R. L., & Rosenthal, R. (2008). Assessing the effect size of outcome research.

Ross, S. M., & Morrison, G. R. (2004). Experimental research methods. *Handbook of research on educational communications and technology, 2*, 1021-1043.

Santa-Maria, Dyson, L. a., & C, M. (2008). *The effect of violating visual conventions of a website on user performance and disorientation: how bad can it be?* Paper presented at the Proceedings of the 26th annual ACM international conference on Design of communication.

Schade, A. (Producer). (2015, 8 16). Supporting Mobile Navigation in Spite of a Hamburger Menu. *nngroup.* Retrieved from https://www.nngroup.com/articles/support-mobile-navigation/

Schröder, S., & Ziefle, M. (2008). *Making a completely icon-based menu in mobile devices to become true: a user-centered design approach for its development.* Paper presented at the Proceedings of the 10th international conference on Human computer interaction with mobile devices and services.

Shneiderman, B., & Hochheiser, H. (2001). Universal usability as a stimulus to advanced interface design. *Behaviour & Information Technology, 20*(5), 367-376.

Singleton, J. (Producer). (2015, 05 14). Should we be using Hamburger menus in Desktop sites? | Obergine. Retrieved from https://obergine.com/news-and-blog/2015/may-2015/should-we-be-using-hamburger-menus-in-desktop-site

Sutton, R. I., & Staw, B. M. (1995). What theory is not. *Administrative science quarterly*, 371-384.

Tsiodoulos, D. (2016a). *Comparison of hamburger and bottom bar menu on mobile devices for three level navigation*. Retrieved from Stockholm:

Tsiodoulos, D. (2016b). Comparison of hamburger and bottom bar menu on mobile devices for three level navigation. In.

Vitor Casadei, T. G., Luciana Zaina. (2017). *Investigating accessibility issues of UI mobile design patterns in online communities: a virtual ethnographic study.* Paper presented at the In Proceedings of the XVI Brazilian Symposium on Human Factors in Computing Systems.

Yu, B. M., & Roh, S. Z. (2002). The effects of menu design on information-seeking performance and user's attitude on the World Wide Web. *Journal of the American Society for Information Science and Technology, 53*(11), 923-933.

Zhao, S., & Balakrishnan, R. (2004). *Simple vs. compound mark hierarchical marking menus.* Paper presented at the Proceedings of the 17th annual ACM symposium on User interface software and technology, New York.

10. Appendices

10.1 Appendix A

10.1.1　　Participant Information Sheet

1. **Research Project Title**

   An usability and universal design investigation into hamburger menus

2. **Invitation**

   You are being invited to take part in this research project. Before you decide to do so, it is important you understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part. Thank you for reading this.

3. **What is this project's purpose?**

   This research project aims to investigate the usability of different navigation designs available in different web applications. It aims to find out if the available menu designs in web applications are convenient for the users or not.

4. **Why have I been chosen?**

   You have been chosen because as participant because as internet user, you will have experience of using various applications available online.

5. **Do I have to take part?**

   It is solely your decision whether to take part or not. If you decide to take part, you can keep a copy of this information sheet. You can withdraw anytime without giving any reasons.

6. **What will happen to me if I take part?**

   You will be asked to perform few tasks which involves using a website. The estimated time for the tasks is 2 to 3 minutes. After that, you will be asked to

complete a questionnaire which should take no more than 5 minutes. The total time is estimated to be no more than 10 minutes.

7. What do I have to do?

Please perform the tasks as instructed. You need to use a website until you finish the tasks.

8. What are the possible disadvantages and risks of taking part?

There are no such tasks which might be risky as it is an act of using a website. The experience will be the same as using online applications in everyday life.

9. What are the possible benefits of taking part?

There are no immediate benefits for those people participating in the experiment. It is hoped that the results of this experiment will be beneficial for those who want to have a better understanding of usability of different menu designs available.

10. What happens if the research study stops earlier than expected?

If the research stops earlier than planned and shows any malfunctions in the system, then the researcher will explain the reasons and try to resolve the issues if possible.

11. Will my taking part in this project be kept confidential?

The data collected from you in this research may be shared anonymously. However, all the information that is collected about you during this research experiment will be kept strictly confidential. Any reports or publications shall not identify you. The anonymous data will not allow anyone to be identified.

12. Will I be recorded, and how will the recorded media be used?

You will not be recorded in a way that identifies you. However, the screen you are using will be recorded for the research purpose. Time taken to complete the tasks will be recorded and the activities within the screen while using the website only will be recorded.

13. **What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives?**

The questionnaire will ask you about your opinions and feedback in relation to the website's menu design and its usability. It is valuable information for the research project as well as will be valuable in designing future software and websites.

14. **Who is organizing the research experiment?**

The research is organized by Nawaraj Khadka, a student currently pursuing Master's degree in Universal design of ICT in Oslo Metropolitan University, Clara Holsts hus, Pilestredet 46, 0167 Oslo.

15. **Contacts for further information**

Nawaraj Khadka, Email: s329934@oslomet.no

10.1.2   Participant Consent Form

RESEARCH CONSENT FORM

Name of Researcher(s)
Nawaraj Khadka
Title of study
An usability and universal design investigation into hamburger menus

Please read and complete this form carefully. If you are willing to participate in this study, mark the appropriate responses and sign and date the declaration at the end. If you do not understand anything and would like more information, please ask.

• I have had the research satisfactorily explained to me in verbal and / or written form by the researcher.	**YES / NO**
• I understand that the research will involve recording of the screen, time involved, use of laptop and internet solely for the research purpose followed by a short interview of no more than 10 minutes.	**YES / NO**
• I understand that I may withdraw from this study at any time without having to give an explanation. This will not affect my future care or treatment.	**YES / NO**
• I understand that all information about me will be treated in strict confidence and that I will not be named in any written work arising from this study.	**YES / NO**

• I understand that you will be discussing the progress of your research with the supervisor assigned for you at Oslo Metropolitan University.	**YES / NO**

I freely give my consent to participate in this research study and have been given a copy of this form for my own information.

Signature: …………………………………………………………….………….

Date: …………………………………………………………………………...

10.1.3   Pre-Experiment Questionnaires

Questions	Description	Answer
What is your age-group?	1. 18-25 2. 26-30 3. 31-35 4. 36-40 5. 41-45 6. 46-50 7. 51-55 8. 56-60 9. 61-65	
What is your level of education?	1. Do not have a formal education. 2. High School 3. Bachelors Level 4. Master's Level	

	5. Doctoral Level	
How often do you use internet?	1. Daily 2. Once in two days 3. Weekly 4. Monthly 5. I don't use	
Since how long you have been using online services/internet?	1. Less than 5 years 2. 5- 10 years 3. 11-15 years 4. Above 15 years	
Do you have experience of using websites or mobile applications?	1. Website 2. Mobile 3. Both 4. None	

Table 41: Pre-Experiment Questionnaires

10.1.4   Post-Experiment Questionnaires

For each of the questions below, circle the response which best characterizes how you feel about the experiment, where 1= Strongly Disagree,2=Disagree,3=Neither Agree nor Disagree,4=Agree, 5=Strongly Agree.

Tasks

S.N.	Statements	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	The tasks were easy to complete.	1	2	3	4	5

| 2 | The tasks were interesting. | 1 | 2 | 3 | 4 | 5 |
| 3 | Tasks were easy to understand and was well-explained. | 1 | 2 | 3 | 4 | 5 |

Table 42: Post Experiment Questionnaires on Tasks

User Interface

S.N.	Statements	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	Text is easy to read.	1	2	3	4	5
2	The color is well balanced and visually pleasing.	1	2	3	4	5
3	The front page (homepage) looks appealing.	1	2	3	4	5
4	The design is simple.	1	2	3	4	5

Table 43:Post Experiment Questionnaires on User Interface

Navigation menu

S.N.	Statements	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	Navigation menu was easy to discover.	1	2	3	4	5
2	I have seen similar kind of navigation design before as well.	1	2	3	4	5
3	It was easy to locate the item I was searching for.	1	2	3	4	5
4	I prefer this navigation design in my smartphone as well.	1	2	3	4	5
5	It is easy to go deeper into the website with this menu.	1	2	3	4	5
6	I found the navigation design	1	2	3	4	5

| 7 | I recommend similar navigation design approach in other websites too. | 1 | 2 | 3 | 4 | 5 |

Table 44:Post Experiment Questionnaires on Navigation menu

Thank you for your participation.

10.2 Appendix B

10.2.1 Preliminary samples of Prototype

10.2.1.1 Pages and menu levels

Prototype Name: Oslo Shop

a. Pages

1. Home (default page)
2. Item List (page shown after clicking on each menu)
3. Details (page shown after user clicks on details of each item in item list page)

b. Menu

1. Men
   - Level One Menu 1
     - o Level Two Menu 1
       - ▪ Level Three Menu1
       - ▪ Level Three Menu2
     - o Level Two Menu 2
       - ▪ Level Three Menu1
       - ▪ Level Three Menu2

- Level One Menu 2
  - Level Two Menu 1
    - Level Three Menu1
    - Level Three Menu2
  - Level Two Menu 2
    - Level Three Menu1
    - Level Three Menu2

2. Women

   Menu level same as men

3. KidsWear

   Menu level up to level two only

6.2.1.9 Prototype with hidden navigation
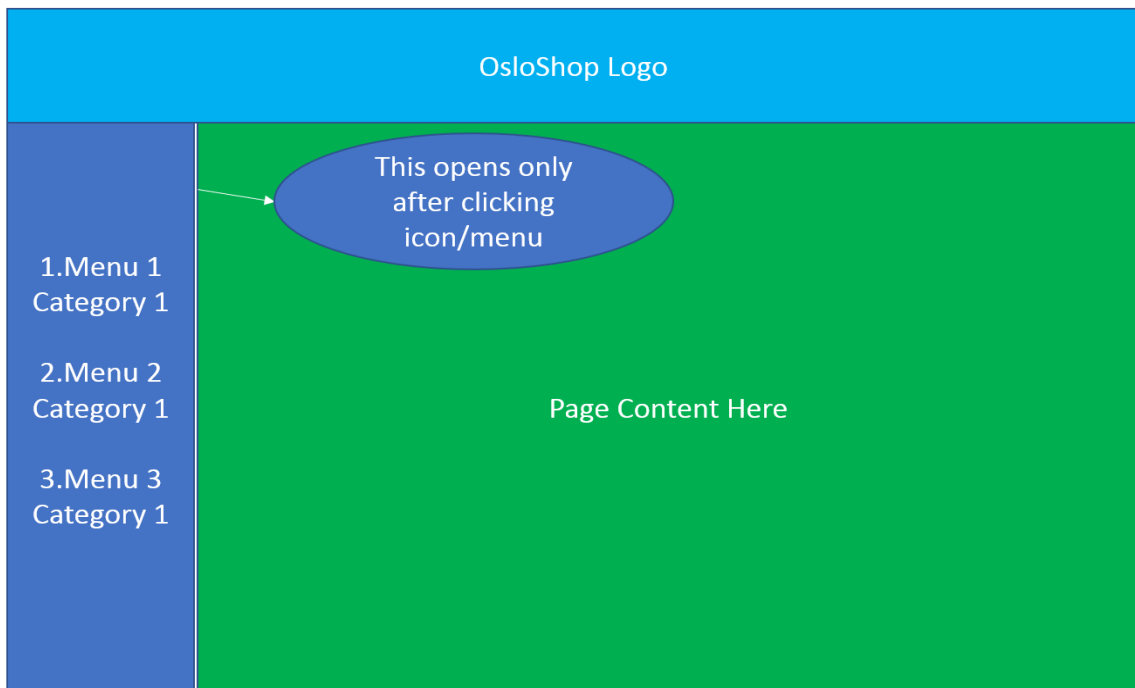
Figure 31:Sample of Prototype with hamburger navigation

10.2.1.2.1 Code Snippets

Html Markup

```
<div>

  <nav>

    <ul>

      <li>

        <a>first level</a>

      </li>

      <li>

        <a>second level</a>

        <ul>

          <li><a>second one</a></li>

          <li>

            <a>second one</a>

            <ul>

              <li><a>third level</a></li>

              <li>

                <a>third level 2</a>

                <ul>

                  <li><a>Fourth level</a></li>

                </ul>

              </li>

            </ul>

          </li>

        </ul>

      </li>

    </ul>

  </nav>

  <div>
```

Button with icon

<button type="button" id="sidebarCollapse" class="navbar-btn active" aria-label="MenuButton" title="MenuButton">

</button>

Javascript Code snippet

```
<script type="text/javascript">

  $(document).ready(function () {

    $('#sidebarCollapse').on('click', function () {

      $('#sidebar').toggleClass('active');

      $(this).toggleClass('active');

    });

  });

</script>
```

6.2.1.10   Prototype with hidden navigation and without hamburger icon

10.2.1.2.2 Code Snippets

Html Markup

```
<div>

  <nav>

    <ul>

      <li>

        <a>first level</a>

      </li>

      <li>

        <a>second level</a>

        <ul>

          <li><a>second one</a></li>

          <li>

            <a>second one</a>

            <ul>

              <li><a>third level</a></li>

              <li>
```

```
              <a>third level 2</a>

              <ul>

                <li><a>Fourth level</a></li>

              </ul>

            </li>


        </ul>

      </li>

    </ul>

  </li>

  </ul>

</nav>

<div>
```

Button for expanding and closing with "Menu"

```
<button type="button" id="sidebarCollapse" class="navbar-btn active" aria-label="MenuButton"
title="MenuButton">

MENU

</button>
```

Javascript Code Snippet

```
<script type="text/javascript">

  $(document).ready(function () {

    $('#sidebarCollapse').on('click', function () {

      $('#sidebar').toggleClass('active');

      $(this).toggleClass('active');

    });

  });

</script>
```

6.2.1.11   Prototype with tab navigation
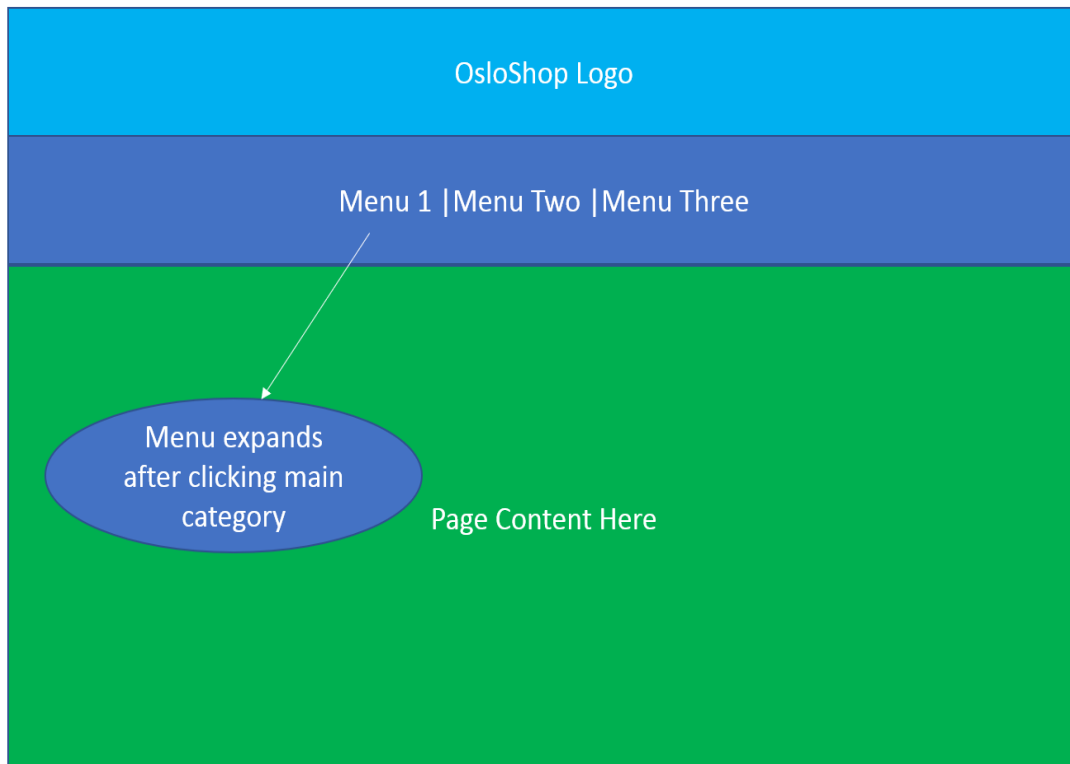
Figure 32:Sample of Prototype with tab navigation

10.2.1.2.3 Code Snippets

Html Markup

```
<ul>

   <li>

      <a>First Level</a>

      <ul>

         <li>

            <ul>

               <li>

                  <div>

                     <p>Second Level</p>
```

```
          </div>
        </li>
        <li>Third Level</li>
        <li>
        <li>Fourth Level</li>
        </li>
      </ul>
    </ul>
  </li>
</ul>
```

10.3 Appendix C

10.3.1 Participants Data

10.3.1.1   Total Task Completion Time

10.3.1.1.1 Hidden Navigation with hamburger icon

S.N.	Task One	Task Two	Task Three	Task Four	Task Five	Task Six
1	4.00	6.00	4.00	7.00	8.00	70.00
2	4.00	7.00	5.00	7.00	14.00	82.00
3	3.00	9.00	7.00	9.00	11.00	110.00
4	3.00	9.00	9.00	8.00	12.00	95.00
5	2.00	8.00	8.00	9.00	9.00	82.00
6	4.00	8.00	7.00	9.00	11.00	84.00
7	5.00	7.00	8.00	7.00	13.00	114.00

8	3.00	11.00	9.00	10.00	9.00	90.00
9	2.00	6.00	7.00	11.00	14.00	110.00
10	4.00	14.00	11.00	10.00	10.00	90.00
11	3.00	5.00	7.00	6.00	15.00	110.00
12	5.00	12.00	10.00	9.00	11.00	110.00
13	3.00	9.00	7.00	7.00	9.00	80.00
14	4.00	7.00	5.00	11.00	10.00	90.00
15	3.00	7.00	6.00	9.00	10.00	85.00

Table 45:Total Task Completion time in seconds: Hidden Navigation with hamburger icon design

10.3.1.1.2Hidden Navigation without hamburger icon

S.N.	Task One	Task Two	Task Three	Task Four	Task Five	Task Six
1	3.00	12.00	6.00	6.00	9.00	95.00
2	3.00	13.00	7.00	9.00	10.00	110.00
3	4.00	7.00	9.00	10.00	13.00	120.00
4	4.00	9.00	7.00	9.00	15.00	95.00
5	2.00	8.00	9.00	11.00	12.00	100.00
6	4.00	8.00	10.00	12.00	13.00	90.00

7	3.00	9.00	10.00	9.00	8.00	80.00
8	5.00	10.00	8.00	8.00	10.00	73.00
9	2.00	11.00	10.00	11.00	11.00	94.00
10	4.00	9.00	8.00	10.00	9.00	86.00
11	3.00	5.00	6.00	9.00	8.00	61.00
12	2.00	8.00	9.00	7.00	9.00	76.00
13	4.00	11.00	12.00	10.00	14.00	114.00
14	5.00	9.00	13.00	12.00	9.00	95.00
15	3.00	8.00	7.00	8.00	9.00	75.00

Table 46: Total Task Completion time in seconds: Hidden Navigation without hamburger icon design

10.3.1.1.3 Tab navigation with mega drop-down menu

S.N.	Task One	Task Two	Task Three	Task Four	Task Five	Task Six
1	2.00	9.00	4.00	9.00	10.00	76.00
2	2.00	8.00	6.00	10.00	11.00	74.00
3	3.00	10.00	8.00	9.00	12.00	60.00
4	3.00	7.00	7.00	8.00	8.00	50.00
5	1.00	6.00	9.00	7.00	7.00	52.00

6	3.00	6.00	6.00	8.00	9.00	56.00
7	3.00	8.00	8.00	9.00	11.00	63.00
8	2.00	8.00	7.00	9.00	9.00	67.00
9	1.00	7.00	6.00	7.00	6.00	47.00
10	2.00	8.00	7.00	8.00	9.00	56.00
11	2.00	7.00	9.00	8.00	10.00	58.00
12	3.00	10.00	11.00	10.00	12.00	68.00
13	3.00	6.00	9.00	11.00	14.00	59.00
14	2.00	8.00	8.00	9.00	9.00	51.00
15	4.00	10.00	7.00	5.00	10.00	22.00

Table 47: Total Task Completion time in seconds: Tab navigation with mega drop-down menu

10.4   Appendix D

10.4.1 Total Task Errors

10.4.1.1   Hidden Navigation with hamburger icon

S.N.	Task One	Task Two	Task Three	Task Four	Task Five	Task Six
1	2	0	2	3	1	3
2	1	1	1	2	2	2

3	3	2	1	2	0	3
4	0	2	0	2	3	4
5	2	3	2	3	1	2
6	0	1	1	1	2	1
7	1	1	3	4	2	5
8	3	2	2	2	1	6
9	1	1	3	2	2	2
10	1	0	2	1	3	4
11	2	3	2	1	1	7
12	0	1	2	0	1	3
13	2	2	3	2	0	2
14	1	1	1	0	2	3
15	3	0	0	0	1	5

Table 48:Total Errors: Hidden Navigation with hamburger icon design

10.4.1.2   Hidden Navigation without hamburger icon

S.N.	Task One	Task Two	Task Three	Task Four	Task Five	Task Six
1	2	2	2	2	2	4
2	1	0	4	3	3	2

3	1	1	2	2	1	3
4	2	2	0	0	2	0
5	0	0	1	1	2	2
6	2	2	2	2	1	4
7	1	1	5	5	0	3
8	2	2	3	3	1	5
9	1	1	2	2	3	5
10	0	2	1	1	2	3
11	1	1	0	0	1	2
12	3	3	2	2	0	4
13	2	0	1	1	1	2
14	2	1	3	3	3	3
15	1	1	0	0	2	5

Table 49:Total Errors: Hidden Navigation without hamburger icon design

10.4.1.3   Tab navigation with mega drop-down menu

S.N.	Task One	Task Two	Task Three	Task Four	Task Five	Task Six
1	0	0	3	1	2	1
2	1	1	2	2	1	3
3	2	2	0	1	2	4

4	1	1	1	2	2	1
5	2	2	2	1	0	2
6	1	1	0	1	2	2
7	0	3	2	2	1	3
8	2	0	1	1	2	1
9	1	1	1	3	1	0
10	0	0	2	2	2	0
11	3	1	1	0	0	2
12	2	1	2	1	1	2
13	1	2	1	2	3	1
14	1	0	1	0	1	3
15	2	2	2	2	1	4

Table 50:Total Errors: Tab navigation with mega drop-down menu

10.5   Appendix E

10.5.1 Participants Responses towards Experimental Condition

10.5.1.1 User Interface

Statement 1: Text is easy to read.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	4.00	3.00	5.00
2	4.00	3.00	4.00

3	3.00	4.00	3.00
4	4.00	4.00	4.00
5	2.00	5.00	4.00
6	3.00	2.00	3.00
7	5.00	3.00	3.00
8	4.00	5.00	4.00
9	3.00	3.00	4.00
10	2.00	4.00	5.00
11	4.00	2.00	5.00
12	4.00	3.00	4.00
13	3.00	4.00	2.00
14	4.00	5.00	3.00
15	5.00	4.00	3.00

Table 51:Response Score: Text is easy to read.

Statement 2: The design is simple.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	4.00	4.00	5.00
2	4.00	4.00	4.00

3	4.00	4.00	3.00
4	5.00	2.00	5.00
5	5.00	5.00	4.00
6	5.00	3.00	2.00
7	3.00	4.00	3.00
8	4.00	3.00	4.00
9	3.00	5.00	3.00
10	3.00	4.00	4.00
11	4.00	4.00	3.00
12	4.00	3.00	5.00
13	3.00	4.00	4.00
14	2.00	5.00	3.00
15	3.00	3.00	4.00

Table 52:Response Score: The design is simple.

Statement 3: The color is well balanced and visually pleasing.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	5.00	5.00	5.00
2	4.00	4.00	2.00

3	4.00	2.00	4.00
4	5.00	4.00	5.00
5	4.00	5.00	3.00
6	5.00	3.00	4.00
7	3.00	4.00	3.00
8	4.00	3.00	3.00
9	3.00	5.00	4.00
10	3.00	3.00	5.00
11	2.00	4.00	5.00
12	4.00	2.00	4.00
13	3.00	4.00	3.00
14	4.00	5.00	4.00
15	3.00	3.00	4.00

Table 53:Response Score: Color is well balanced and visually pleasing.

10.5.1.1.1 Test for normal distribution

Statements	Menu Design	Shapiro-Wilk		
		Statistic	df	Sig.
	Hamburger menu design	.882	15	.050

Text is easy to read	Hidden navigation without hamburger menu	.896	15	.082
	Tab Navigation	.888	15	.063
The design is simple	Hamburger menu design	.888	15	.050
	Hidden navigation without hamburger menu	.882	15	.063
	Tab Navigation	.888	15	.077
The color is well balanced and visually pleasing	Hamburger menu design	.888	15	.063
	Hidden navigation without hamburger menu	.885	15	.056
	Tab Navigation	.881	15	.050

Table 54: Normality test for responses on user interface

10.5.1.1.2 Test of homogeneity of variances

Statements	Levene Statistic	df1	df2	Sig.
Text is easy to read	0.199	2	42	0.820
The design is simple	0.198	2	42	0.955
The color is well balanced	0.353	2	42	0.704

	and visually pleasing				

Table 55: Response related to user interface (Test for homogeneity of variances)

10.5.1.1.3 Anova Statistics

Statement 1: Text is easy to read.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.178	2	.089	.102	.902
Within Groups	36.133	42	.860		
Total	36.311	44			

Table 56: One-way Anova Statistics (text is easy to read)

Statement 2: The design is simple.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.933	2	.467	.103	. 919
Within Groups	20.267	42	.483		
Total	21.200	44			

Table 57: One-way Anova Statistics (the design is simple)

Statement 3: The color is well balanced and visually pleasing.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.178	2	.089	.099	.906
Within Groups	37.600	42	.895		
Total	37.778	44			

Table 58: One-way Anova Statistics (The color is well balanced and visually pleasing)

10.5.1.2   Usability of navigation

Statement 4: Navigation Menu was easy to discover.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	5.00	4.00	4.00
2	3.00	4.00	5.00
3	4.00	4.00	3.00
4	2.00	5.00	3.00
5	4.00	2.00	4.00
6	3.00	5.00	5.00
7	5.00	3.00	4.00
8	4.00	4.00	5.00

9	3.00	3.00	2.00
10	4.00	4.00	4.00
11	3.00	5.00	4.00
12	2.00	3.00	3.00
13	5.00	3.00	3.00
14	3.00	4.00	4.00
15	3.00	3.00	5.00

Table 59: Response Score: Discoverability of navigation menu

Statement 5: It was easy to locate the items I was looking for.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	5.00	4.00	4.00
2	3.00	5.00	4.00
3	4.00	2.00	4.00
4	2.00	3.00	5.00
5	4.00	4.00	2.00
6	3.00	3.00	5.00
7	4.00	4.00	5.00
8	5.00	3.00	4.00

9	2.00	4.00	3.00
10	4.00	5.00	4.00
11	4.00	4.00	3.00
12	3.00	3.00	2.00
13	3.00	3.00	5.00
14	4.00	4.00	3.00
15	5.00	3.00	3.00

Table 60: Response Score: Easiness to locate items.

Statement 6: I prefer this kind of navigation in my smartphone as well.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	3.00	3.00	4.00
2	2.00	4.00	5.00
3	4.00	3.00	4.00
4	3.00	4.00	2.00
5	2.00	4.00	4.00
6	5.00	4.00	2.00
7	5.00	3.00	3.00
8	4.00	2.00	3.00

9	3.00	3.00	2.00
10	3.00	5.00	4.00
11	4.00	3.00	3.00
12	4.00	3.00	4.00
13	3.00	4.00	2.00
14	5.00	4.00	5.00
15	2.00	5.00	3.00

Table 61: Response Score: Preference on smartphone

Statement 7: It is easy to go deeper into the website with this menu.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	5.00	4.00	3.00
2	5.00	5.00	4.00
3	4.00	4.00	3.00
4	3.00	2.00	3.00
5	3.00	4.00	4.00
6	3.00	5.00	3.00
7	2.00	4.00	5.00
8	4.00	2.00	3.00

9	3.00	3.00	2.00
10	2.00	5.00	4.00
11	4.00	3.00	4.00
12	4.00	3.00	3.00
13	3.00	2.00	4.00
14	5.00	3.00	4.00
15	2.00	3.00	5.00

Table 62:Response Score: Easiness to go deeper.

Statement 8: I found navigation design pleasing while performing task.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	3.00	3.00	4.00
2	4.00	4.00	5.00
3	5.00	3.00	4.00
4	4.00	2.00	3.00
5	2.00	4.00	4.00
6	3.00	3.00	2.00
7	2.00	5.00	3.00
8	4.00	5.00	3.00

9	5.00	3.00	4.00
10	5.00	4.00	3.00
11	4.00	3.00	4.00
12	3.00	4.00	5.00
13	3.00	3.00	5.00
14	3.00	4.00	4.00
15	5.00	4.00	5.00

Table 63: Response Score: Pleasing while performing tasks.

10.5.1.2.1 Test for normal distribution

Statements	Menu Design	Shapiro-Wilk		
		Statistic	df	Sig.
Easy to discover	Hamburger menu design	.887	15	.061
	Hidden navigation without hamburger menu	.888	15	.063
	Tab Navigation	.881	15	.050
Easy to locate items	Hamburger menu design	.891	15	.070
	Hidden navigation without hamburger menu	.883	15	.052
	Tab Navigation	.885	15	.056
	Hamburger menu design	.889	15	.064

Preference on smartphone	Hidden navigation without hamburger menu	.883	15	.052
	Tab Navigation	.882	15	.052
Easiness to go deeper into the website	Hamburger menu design	.889	15	.064
	Hidden navigation without hamburger menu	.889	15	.064
	Tab Navigation	.883	15	.052
Pleasantness while performing task	Hamburger menu design	.882	15	.052
	Hidden navigation without hamburger menu	.883	15	.052
	Tab Navigation	.881	15	.050

Table 64:Normality test for responses on usability of navigation

10.5.1.2.2 Test of Homogeneity of variances

Statements	Levene Statistic	df1	df2	Sig.
Navigation menu was easy to discover.	0.287	2	42	0.752
It was easy to locate the	0.413	2	42	0.665

items I was looking for.				
I prefer this kind of navigation in my smartphone as well.	0.884	2	42	0.421
It is easy to go deeper into the website with this menu.	0.907	2	42	0.411
I found navigation design pleasing while performing task.	.735	2	42	0.485

Table 65: Statements on Usability of Navigation (Test for homogeneity of variances)

10.5.1.2.3 Anova Statistics

Statement 4: Navigation Menu was easy to discover.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.844	2	.422	.487	.618
Within Groups	36.400	42	.867		

	Sum of Squares	df			
Total	37.244	44			

Statement 5: It was easy to locate the items I was looking for.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.133	2	.067	.074	.929
Within Groups	37.867	42	.902		
Total	38.000	44			

Table 67: Anova Statistics (Easy to locate items)

Statement 6: I prefer this kind of navigation in my smartphone as well.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.533	2	.267	.275	.761
Within Groups	40.667	42	.968		
Total	41.200	44			

Table 68:Anova Statistics (Preference on smartphone)

Statement 7: It is easy to go deeper into the website with this menu.

	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	.178	2	.089	.091	.913
Within Groups	41.067	42	.978		
Total	41.244	44			

Table 69: Anova Statistics (Easiness to go deeper into website)

Statement 8: I found navigation design pleasing while performing task.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.578	2	.289	.331	.720
Within Groups	36.667	42	.873		
Total	37.244	44			

Table 70: Anova Statistics (Pleasantness while performing tasks)

10.5.1.3 Tasks

Statement 9: The tasks were easy to complete.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	4.00	5.00	3.00

2	4.00	4.00	5.00
3	3.00	3.00	3.00
4	5.00	5.00	5.00
5	4.00	4.00	2.00
6	4.00	3.00	4.00
7	5.00	4.00	3.00
8	4.00	4.00	5.00
9	3.00	5.00	3.00
10	3.00	2.00	5.00
11	4.00	3.00	4.00
12	3.00	4.00	3.00
13	2.00	3.00	4.00
14	3.00	4.00	4.00
15	5.00	3.00	4.00

Table 71: Response Score: Tasks were easy to complete.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	2.00	2.24	1.73

2	2.00	2.00	2.24
3	1.73	1.73	1.73
4	2.24	2.24	2.24
5	2.00	2.00	1.41
6	2.00	1.73	2.00
7	2.24	2.00	1.73
8	2.00	2.00	2.24
9	1.73	2.24	1.73
10	1.73	1.41	2.24
11	2.00	1.73	2.00
12	1.73	2.00	1.73
13	1.41	1.73	2.00
14	1.73	2.00	2.00
15	2.24	1.73	2.00

Table 72:Response Score: Tasks were easy to complete (transformed score after square root)

Statement 10: The tasks were interesting.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	5.00	3.00	4.00

2	4.00	4.00	5.00
3	5.00	4.00	4.00
4	5.00	5.00	5.00
5	4.00	4.00	3.00
6	4.00	4.00	5.00
7	5.00	4.00	4.00
8	4.00	5.00	4.00
9	4.00	5.00	5.00
10	4.00	4.00	4.00
11	4.00	3.00	4.00
12	3.00	5.00	4.00
13	4.00	4.00	4.00
14	3.00	3.00	5.00
15	3.00	3.00	5.00

Table 73: Response Score: Tasks were interesting.

Statement 11: The tasks were easy to understand and well explained.

S.N.	Hidden navigation with hamburger icon	Hidden navigation without hamburger icon	Tab navigation design
1	4.00	5.00	4.00

2	4.00	4.00	3.00
3	4.00	4.00	5.00
4	3.00	3.00	4.00
5	3.00	4.00	4.00
6	5.00	4.00	4.00
7	4.00	4.00	5.00
8	4.00	5.00	5.00
9	4.00	3.00	5.00
10	3.00	4.00	4.00
11	3.00	3.00	4.00
12	4.00	5.00	3.00
13	5.00	3.00	3.00
14	5.00	3.00	4.00
15	3.00	5.00	5.00

Table 74: Response Score: Tasks were easy to understand and well explained.

10.5.1.3.1 Test for normal distribution

Statements	Menu Design	Shapiro-Wilk		
		Statistic	df	Sig.
	Hamburger menu design	.235	15	.056

The tasks were easy to complete	Hidden navigation without hamburger menu	.235	15	.056
	Tab Navigation	.204	15	.050
The tasks were interesting	Hamburger menu design	.815	15	.006
	Hidden navigation without hamburger menu	.823	15	.007
	Tab Navigation	.766	15	.001
The tasks were easy to understand and well explained	Hamburger menu design	.817	15	.006
	Hidden navigation without hamburger menu	.818	15	.007
	Tab Navigation	.817	15	.006

Table 75: Normality test on responses on task design

10.5.1.3.2 Test of homogeneity of variances

Statements	Levene Statistic	df1	df2	Sig.
The tasks were easy to complete	0.50	2	42	0.952
The tasks were interesting	0.33	2	42	0.967
The tasks were easy to understand	0.061	2	42	0.941

	and well explained				

<center>Table 76: Responses on task design (Test for homogeneity of variances)</center>

10.5.1.3.3 Anova Statistics

Statement 9: Tasks were easy to complete.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.002	2	.001	.022	.979
Within Groups	2.402	42	.057		
Total	2.404	44			

<center>Table 77: Tasks were easy to complete (Anova Statistics)</center>

Statement 10: Tasks were interesting.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.933	2	0.467	0.967	.388
Within Groups	20.267	42	.483		
Total	21.200	44			

<center>Table 78:Tasks were interesting (Anova statistics)</center>

Statement 11: Tasks were easy to understand and well-explained.

<center>148</center>

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.044	2	0.22	0.27	.973
Within Groups	34.267	42	.816		
Total	34.311	44			

4. Table 79: Tasks were easy to understand and well-explained (Anova Statistics)