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< Universal Design & Usability investigation into Flat Design and Skeuomorphic interfaces. Case study of a News website >

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Preface

The completion of this Master thesis is in fulfilment of the requirements of a Master studies in Universal Design of ICT at Oslo Metropolitan University. The thesis aims to investigate the usability and universal design in skeuomorphism and flat design with a case study of a news media website.

My sincere gratitude goes to my supervisor Pietro Murano, for his continuous support and valuable comments and guidance. I am also indebted to the participants recruited in this research, for taking out time to be part of this. I am indebted to all the professors and teaching assistants that were instrumental in imparting knowledge into me in the two years of this Master program. I am also thankful for my colleagues and friends I made on this journey. You all have been an encouragement to be better. Finally, I am grateful for the support of my family, which was priceless. I am thankful to God for seeing me through this incredible journey to its successful completion.

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Abstract

Skeuomorphism and Flat Design are the predominant user interface design approaches in technology. Skeuomorphism is a design approach that tries to maintain a link between the digital interface components and real-world equivalents. Interface components such as icons and buttons project a resemblance in appearance or function to real-world items by employing metaphors. Flat design, on the other hand, creates interfaces with a flat and 2-dimensional feel, excluding ornamental features and real-world metaphors. These design trends have their strengths and weaknesses. This study puts importance on determining which design approach provides better conditions for higher performance, improved usability and universal design. Ensuring that any user irrespective of impairments can efficiently utilise an interface is paramount to universal design. This study investigated the effects of these design approaches on visually unimpaired users and visually impaired short-sighted user when using a news media website. Two website prototypes with each design approach where designed and used to perform user experiments. Post experiment questionnaires on usability and user satisfaction were conducted, and user perceptions were qualitatively analysed, leading to the statistical analysis of data from the laboratory styled user experients. The difference in performance in terms of task completion time was mostly not significant between both interface types and between both user groups. The flat designed interface faired better in usability and user satisfaction ratings and was also more likely to be attuned to the principles of universal design. After a comprehensive consultation of literary works related to this study, no systematic studies have explored the main design trends regarding how they affect people living with physical impairments and how they can accommodate universal design dictates. Therefore, this is a unique research, and if implemented on a larger scale with further specifications, would be invaluable to advancing usability and universal design in human-computer interaction.

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List of Acronyms

Abbreviation	**Meaning**
ANOVA	Analysis of Variance
HCI	Human-computer interaction
ISO	International Organisation for Standardisation
IT	Information Technology
MDflat	The median value for the flat interface
MDimp	The median value for the visually impaired user group
MDskeu	The median value for the skeuomorphic interface
MDunimp	The median value for the visually unimpaired impaired user group
OS	Operating System
Skeu	Skeuomorphic interface
UD	Universal Design
UI	User Interface
URL	Uniform Resource Locator
WCAG	Web Content Accessibility Guidelines

1 Introduction

The essence of an interactive system or technology is to enable users to communicate with technology and perform meaningful tasks related to their everyday activities using the systems User Interface (UI). The interface of an application, system or device essentially creates a link between the physical world and the digital world, and between humans and the system. In computing terms to design, an interface implies developing and implementing interface functionalities. In this digital world, where products and businesses usually possess a digital interface, it is vital to put more emphasis on creating more suitable interfaces. The appearance of an interface to users is of importance when drawing up sketch designs, especially when the aim is to attract more users to use and reuse the interface. A fully functioning website which allows users to buy shoes and clothes online may possess an interface that makes it difficult for users to select items and load them into their online carts. Users may see the icon size or use of colours in a mobile app as unattractive, and prevent other users with visual impairments from correctly identifying items. Functionality and performance of a system is not everything; appearance matters. The appearance and design of an interface can pose usability problems for users, and discourage many from utilising such an interface in future. Eroglu et al. have discussed the importance of font and layout in websites, and how they positively influence the rate at which consumers visit a website and its effect on responses from online shoppers (Eroglu, Machleit, & Davis, 2001).

Skeuomorphism and Flat Design are two primary design approaches which have been predominant and been in competition with each other in the past couple of years. Skeuomorphism has been in use long before flat design and is not just used in creating digital interfaces but in non-digital fields such as architecture, ceramics, and interior design (Rose, 2013). Skeuomorphism is a design approach that tries to maintain a link between the digital interface components and real-world equivalents. By using metaphors, interface components such as icons and buttons project a resemblance in appearance or function to real-world items.

Metaphors used in UIs allow a person to determine how a mechanism functions just by looking at it, depending on previous knowledge of the way similar elements in real-life work. Metaphors thus enable users to easily relate with graphical items of an interface, without having used the interface previously. A prevalent example is in the use of a floppy disk graphic to represent the save button. A user can tell that that button is used to store or save current work permanently; however, this may also be outdated as young users in this generation grew up when floppy disks that were being eased out of circulation. Skeuomorphism makes use of various stylistic and ornamental features that give an interface a three-dimensional feel in which elements on the UI may appear to be elevated. Flat Design, on the other hand, creates interfaces with a flat and 2-dimensional sense, excluding ornamental features and real-world metaphors. It has been referred to by Microsoft as an authentically digital design style, which led to more designers making use of it ("Flat Design: Its Origins, Its Problems, and Why Flat 2.0 Is Better for Users," n.d.-a). A flat design strives to produce more abstraction, simplicity and symbolism in an interface (Zhang, Wang, & Shi, 2017).

Proponents of Flat design have argued that skeuomorphic interfaces employ unnecessary ornamental features that, and gets in the way of users. In contrast, opponents of flat design say that it does not provide good affordance necessary for users to quickly identify a graphic element and the way such component is used. Affordance can be in the form of any feature added to interface components such as icons, buttons and links that enables a user to identify these components quickly. Examples include shadows that elevate buttons, colours for text links, icons with suggestive metaphors. Determining the role age and technological skill level play in users' preference and dislike for a UI design has been researched previously. However, there has been limited research done in perusing these design methods in detail and various contexts. InvestigatIng flat design concerning Universal Design principles is yet to be done. This study builds upon previous research into these contrasting design methods concerning the usability and universality they provide for a News website. There is a meeting point between these two extreme design styles which some have given names such as Flat 2.0, Almost Flat, Skeuominimalism and Material Design.

A universally designed product is created to be usable by more people who possess varying capabilities without the need for an add-on. Technological innovations must be accessible and usable by people living with impairments, people from different backgrounds and other diverse user groups. Irrespective of the design of a UI, the UI must be designed to be inclusive as possible, adhering to universal design principles. An investigation to determine which user interface design approach mostly sticks to the dictates of universal design.

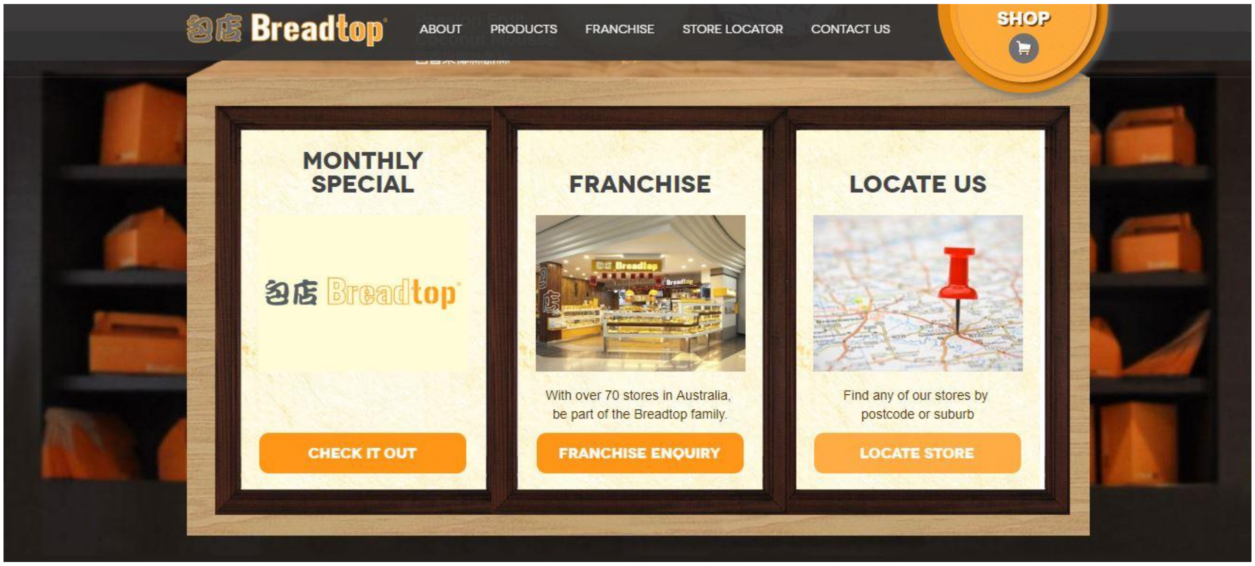


Figure 1-1*. The UI of the Breadtop website showing the skeuomorphic stimuli used in its design; loaves of bread on a shelf (ornamental), pages linked pages placed in a picture frame, a pin on a map signifying the locate us function.*

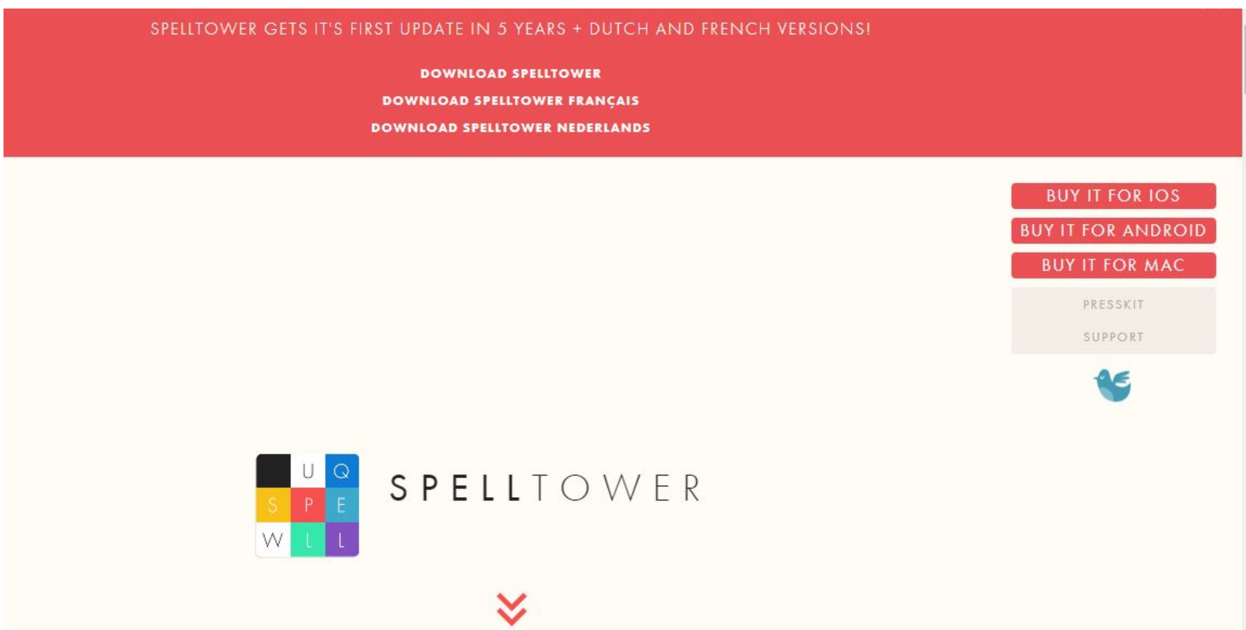


Figure 1-2. *The homepage of the SPELLTOWER website, showing the implementation of Flat Design.*

1.1 Problem Statement

User Interface designs can pose both usability and accessibility challenges for users of news applications or websites. A poorly designed User Interface (UI) can make it difficult for users to identify clickable icons, links, menus, menu items and easily access information on such news websites and applications. Poor design leads to products that are overcomplicated, non-functional and less user-oriented. In contrast, the right design contents create products that are functional, user-oriented, durable and unobtrusive (Pandab, n.d.). The two most common UI design styles, Flat and Skeuomorphic design, offer advantages as well as disadvantages that may not necessarily follow Universal Design and Usability principles. Minimalistic tendencies of flat design may enhance usability and efficiency (Pelet & Taieb, 2017), but information that users feel are necessary and helpful may be missing (Stickel, Pohl, & Milde, 2014).

The choice of interface design style can limit the usability of an app or a website on smaller screens or mobile devices such as tablets and smartphones. For instance, the legibility of a font typeface depends on its design, consequently allowing characters to be distinguished (Pelet & Taieb, n.d.). Pelet and Taieb opined that users should not need to zoom when browsing or typing on a mobile commerce website interface (Pelet & Taieb, 2017). Problematic UIs on such devices may not provide enough affordance for users or may utilise unimportant and excess ornamental decorations that will get in the way of users quickly accessing information and completing tasks. A bevel effect added to buttons informs a user that it is clickable, and a ribbed surface can indicate that dragging a corner can resize a window (Oswald, Kolb, & Others, 2014). Users wrongly take interactive elements for decorations and vice versa, if there is no affordance in an interface component. (Burmistrov, Zlokazova, Izmalkova, & Leonova, 2015). Currently, most modern applications and web technologies have gone down the flat design route. Microsoft Office tools such as MS Word now has a flat outlook compared to Older versions. Google has called there latest interface design method Material Design. Although it is said to be an almost flat design across Google's products, the impression of a flat interface in some parts of their products lingers.

The common trend of designers utilising flat design in creating UIs appears to have resulted from designers and developers joining on the bandwagon of a design approach that was new, refreshing and produced interfaces that were said to be more digital. After Microsoft transitioned to a flat design style called ‘Metro’, it resonated within the technology industry, with praise for its focus on typography and colours (“Flat Pixels: The Battle Between Flat Design And Skeuomorphism,” n.d.). However, previous research has identified usability problems with flat design, one of which is the lack of affordance needed for intuitive manipulation of interface components. Burmistrov et al. concluded that flat interfaces are associated with higher cognitive load (Burmistrov et al., 2015). They supported the opinion of Human-Computer Interaction (HCI) experts who feel that flat designed interfaces should be replaced by interfaces created based on design principles established in HCI and usability engineering research (Burmistrov et al., 2015).

This research will focus on investigating and comparing the level of usability and inclusiveness of these two prominent interface design strategies, with a case study of a news media website.

1.2 Research Questions

In line with the problem statement detailed above, this section outlines the questions that will guide this research. The aim is to carry out quality research that will answer these questions, in doing so bring more clarity to the issues of the design strategies discussed concerning usability and universal design.

1. Skeuomorphic or flat interface; which provides better features for identification and recall of news website content such as icons, links and menu items?
2. Skeuomorphic or flat interface; which enables users to acquire information from news articles, headlines, substories and other items on a news website more efficiently and with the least time spent?
3. Skeuomorphic or flat interface; which provide better usability and user satisfaction for short-sighted visually impaired users and visually unimpaired users using a news website?
4. Skeuomorphic or flat interface; which better allows for a universally designed website?

2 Literature Review

This section details the concepts that inform this topic and how previous research explains them. Experiments and other research work in the topic area are consulted, while state of the art in the design method of UIs are discussed.

2.1 Design

In earlier times, the word design referred to appearances and was related to fields such as automobile, styling, fashion and interiors (Pandab, n.d.). Several definitions exist for the word design depending on the area or industry. As defined in the Merriam-Webster dictionary, it is "to create, fashion, execute, or construct according to plan" ("Definition of DESIGN," n.d.). It is essentially creating something in a structured way or with clearly set out plans. As humans interaction comes natural, we all want to communicate and exchange signals with people, animals, and even non-living things. **Interaction Design** is a term coined by Bill Moggride and Bill Verplank, who were industrial designers (Cooper, Reimann, Cronin, & Noessel, 2014). Moggride felt there was a need to create a new discipline based on what he perceived to be the demands of the design market. "*I felt that there was an opportunity to create a new design discipline, dedicated to creating imaginative and attractive solutions in a virtual world, where one could design behaviours, animations, and sounds as well as shapes. This would be the equivalent of industrial design but in software rather than three-dimensional objects. Like industrial design, the discipline would be concerned with subjective and qualitative values, would start from the needs and desires of the people who use a product or service, and strive to create designs that would give aesthetic pleasure as well as lasting satisfaction and enjoyment. […] so we went on thinking of possible names until I eventually settled on 'interaction design*'" (Moggridge, 2006). Interaction design is more concerned with the creation of interfaces that allow humans to connect and communicate with the digital world. Interaction design also refers to interactive products that are of help to people in their everyday activities *(Lee, 2005).* Cypriano & Pinheiro noted that interaction design consists of two main features that distinguish it from design in other fields (Cypriano & Pinheiro, 2015). It is digital or computer technology related, and it does cover not only aesthetics but also the functional aspects of the systems and products (Cypriano & Pinheiro, 2015). Therefore in designing a UI care, a designer must consider how elements will function and the ease at which a user can make those elements perform their function. A colourful and pretty looking interface is not necessarily a good design.

2.1.1 Affordances

Donald A. Norman introduced the term affordance into HCI and defined it as the aspect of an objects' design that informs how the item should be utilised (Norman, 2002). It was a term initially invented by a perceptual psychologist J.J Gibson. Affordances did not need to be perceived; they could just exist with anyone knowing it was there (Norman, 2008). However, Norman was referring to perceivable affordances, which he later called "signifier" to halt its misuse (Norman, 2008). Affordances or signifiers provide perceivable clues that enable a user to operate a technology intuitively. 3-dimensional effects make users aware of interactive elements on a window; elements that appear raised can be pressed down like a button, while details that seem hollow can be filled up with text ("Flat Design: Its Origins, Its Problems, and Why Flat 2.0 Is Better for Users," n.d.-b).

Figure 2-1*. An interactive toggle switch. The label OFF is the signifier that shows that there are only two states of the switch. Taken from (Pandab, n.d.).*

2.1.2 Metaphors

Metaphors are used to link functionality in the digital world to something in the physical world. Jung et al. appropriately explain it: "In HCI design, the use of metaphors began

as a way of communicating to users what a computer application could do by linking it to something already familiar to the user. A prime example is the desktop metaphor in computing: it conveyed its similarity to the physical desktop through its spatial and file-based information organization, graphic icons and menu labels; and it was similarly amenable to the
workflows and activities associated with traditional offices" (Jung, Wiltse, Wiberg, & Stolterman, 2017). Earlier versions of Apple's iOS were heavy on the use of metaphors to create some form of real relationships. Some of such are still in use, even in other mobile operating systems. The phone icon takes the shape of an old traditional wired telephone, and the email icon made to look like an envelope used to distribute paper mails. Metaphors permeate interface designs and are most associated with realism and skeuomorphism where effort is made to create relationships between digital elements and everyday items in the physical world. "The idea behind this approach is, simply put: Give inexperienced people what they already know: Office people get an office interface, users who use a personal computer in their free time get a living-room interface" (Oswald et al., 2014).

2.2 Skeuomorphism

Historical use of skeuomorphism includes the desktop metaphor established by Alan Kay in 1970, and even further back according to Thomas Brand ("Apple's History of Skeuomorphism," n.d.) with the introduction of the Macintosh. Apple went on to revive this type of design with the introduction of the iPhone in 2007, where skeuomorphism previously used in visual design was adopted to help users that were new to using touch screens (Spiliotopoulos, Rigou, & Sirmakessis, 2018). A perfect definition of skeuomorphism is one given by Wu Lei et al. which states that "Skeuomorphism is the design strategy of the product-user interface design that describes design elements functionally and originally transplanting from the real object" (Wu, Lei, Li, & Li, 2015). The goal is to make it easy for a user to operate digital interface elements because such a person already knows how the real object it is related to in the physical world functions. Skeuomorphism is closely related to the use of affordances and metaphors to make a design more realistic. Skeuomorphic features, therefore, make an interface self-explanatory (Oswald et al., 2014). The use of three-dimensional effects, shadows, lights, texture, and other ornamental features in skeuomorphism is typical. Figure 2-1 shows the use of this design strategy on a website's interface, notice the loaves of bread on a shelf, and linked pages fixed on a picture frame. The effect of skeuomorphism is felt in the design of icons used on mobile and desktop platforms. Most notably on mobile devices, icons play a significant role as the smaller screens only allow for the display of fewer items. The icons on a mobile device, therefore, can go a long way in making a user be informed about the function of the application the icon represents. An example of skeuomorphic icon design is that of the calculator icon on earlier ios versions, which had the symbol of a classical calculator with the plus, division, subtraction and multiplication buttons. The elevation of buttons on the icon gives the effect of a clickable surface. The waste bin basket used to represent the recycle bin function on Windows operating system. Icons in previous skeuomorphic iOS designs were usually shiny and bevelled to provide awareness to users that they can press them on their flat touch screens.

In a criticism of this design method, Li et al. (Li, Shi, Huang, & Chen, 2014) explained that although skeuomorphic designs make UI elements more familiar to users, the culture they emanate from shapes them, making it difficult for users from a different cultural background to relate to them. The authors also stated the disadvantage of the skeuomorph symbols being complex, probably leading to clutter, overload and unclear interfaces.

2.3 Flat Design

Flat design, unlike skeuomorphism, is a minimalistic design strategy that does away with elements and features that help users relate digital interface elements to real-world objects. It became pronounced with Microsoft introducing the Windows 8 Operating System (OS) and Apple following suit to introduce a flatter iOS 7 (Gross, Bardzell, & Bardzell, 2013). This design method seeks to provide a digital environment on screens that do not contain any 3D elements of the real world. Simple User Interface elements, Bold colours utilised, text and font are of more importance (Burmistrov et al., 2015). The main criticism of flat design from HCI experts is that it ignores the 3D nature of the human brain. Removal of metaphors and visual cues created to relate interface elements to real-world properties. Unelevated buttons, exclusion of shadows, glitter and ornamental features. The interface is completely flat! Principles of flat design, as explained in (Cousins, 2013) include:

- **No added effects**: Nothing is added to make elements more realistic. The concept works without embellishment – drop shadows, bevels, embossing, gradients or other tools that add depth.
- **Simple Elements**: Flat design uses many simple user interface elements, such as buttons and icons. Designers often stick to simple shapes, such as rectangles, circles or squares and allow each figure to stand alone.
- **Focus on Typography**: Because of the simple nature of the element in flat design, typography is crucial. The tone of typefaces should match the overall design scheme – a highly embellished font might look odd against a super-simple design. Type should also be bold and worded simply and efficiently, in an effort for the final product to have a consistent tone visually and textually.
- **Focus on colour**: Colour is a large part of flat design. Flat design colour palettes are often much brighter and more colourful than those for other sites.
- **Minimalist Approach**: Flat design is simple by nature and works well with an overall minimalist design approach. Avoid too many bells and whistles in the overall site design. Simple colour and text may be enough. If you want to add visuals, opt for simple photography.

Nielsen Norman's group believe that flat design has inherent usability problems; their "primary objection to flat design is that it tends to sacrifice users' needs for the sake of trendy aesthetics" ("Flat Design: Its Origins, Its Problems, and Why Flat 2.0 Is Better for Users," n.d.-a). They argue that because people have become used to operating popular interface elements without cues, does not mean they do not need them at all. They also state that most advice on the modern flat design style out there encourages designers to create interfaces with very low information density. One of the things that people appreciate is that flat design “offers more clean lines and a lighter, bolder, and more colourful palette of colours to attract the users” (Wu et al., 2015). Window 8’s version of flat design is believed to have sacrificed functionality, hence usability and design best practices for a plane appearance(“When Flat Design Falls Flat,” 2013).

2.4 The Go-Between

Designers began to explore ways to create flat applications without sacrificing usability while introducing affordance to improve clickability and identification. This strategy of adding to flat design is being called several names including semi-flat, almost flat, flat 2.0 and skeuominimalism. In this strategy, the aim to ensure that simplification does not get to the point that usability is affected and that affordances and visual cues are present even if limited. “This design style is mostly flat, but it makes use of subtle shadows, highlights, and layers to create some depth in the UI” (“Flat Design: Its Origins, Its Problems, and Why Flat 2.0 Is Better for Users,” n.d.-b). Google introduced “Material Design” as used in Android, which is a flat design that makes use of shadows and gradients subtly. Sacha Greif stated that it is a design style that “offers the best of both worlds: realism's affordances and subtle hints combined with the purity and simplicity of flat design” (“Flat Pixels: The Battle Between Flat Design And Skeuomorphism,” n.d.). Nielsen Norman Group provided a checklist to check the usability of a flat UI as (“Flat-Design Best Practices,” n.d.):

- Clickability clues are consistent throughout the site.
- Linked elements are salient, have appropriate contrast, and are noticeable.
- Linked elements are located where users would expect them to be.
- There are no ‘red herrings’ — no false targets that look clickable, but aren’t.
- All elements associated with the same piece of content (icon, image, text) are linked and point to the same page.
- Provide feedback whenever there’s a response time lag between a click and the resulting action.

2.5 Interface Types

Different technologies and applications possess varying types of interfaces. The focus of this study is on web technology, a mobile web app and a website in particular.
In research by Idler (Idler, 2013), 100 web professionals completed tasks relating to the clickability of elements on four flat websites. Results showed that the frequency of false alarm errors when using the flat websites varied from 16% to 38%, with an average of 29%, with the authors concluding that reaching an acceptable level of usability in flat websites is a difficult task (Burmistrov et al., 2015). Mobile applications are software apps created to run on mobile devices that possess small-sized screens such as smartphones, tablets, smartwatches and other smart devices. Problems that may occur in the design of mobile applications include; 1—utilising screen space. 2. Interaction mechanisms. 3. Design at large (Nilsson, 2009).

2.6 Universal Design

A perfect definition of Universal Design (UD) was given by the Disability Act of 2005 as "the design and composition of an environment so that it may be accessed, understood and used to the greatest possible extent, In the most independent and natural manner possible, In the widest possible range of situations, without the need for adaptation, modification, assistive devices or specialised solutions, by any persons of any age or size or having any particular physical, sensory, mental health or intellectual ability or disability" (National Disability Authority, n.d.). The focus of UD is on developing products and environments that cater to anyone irrespective of their capabilities and background. It also emphasises the need for the accommodation of diverse user groups to be part of a products' design, not bolted on or not needing the use of an add-on for the tool to be used by some sets of users. Therefore universal design principles are to be implemented in the development of products and not taken into consideration as an afterthought.

The seven principles of Universal Design developed by a group of professionals led by Ronald Mace in North Carolina State University are summarised below, as stated in (Design, n.d.) :

- Principle 1. **Equitable Use**: The design is useful and marketable to people with disabilities
- Principle 2. **Flexibility in use**: The design accommodates a wide range of individual differences and abilities.
- Principle 3. **Simple and Intuitive**: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
- Principle 4. **Perceptible Information**: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
- Principle 5. **Tolerance for Error**: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
- Principle 6. **Low Physical Effort**: The design can be used efficiently and comfortably and with minimum fatigue.
- Principle 7. **Size and Space for Approach and Use**: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

2.7 Usability

A universally designed product is one which is both accessible and usable by all. ISO defines usability as the "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO, 2018). From that definition, we can deduce that the metrics for measuring the usability of a product or system will be effectiveness and efficiency of the product or service, as well as the amount of satisfaction derived by users from using said product or service. A comparative study of the skeuomorphic design of Windows 7 and the flat design of Windows 8 concerning usability showed that

Windows 7 fared better in task success score (effectiveness), the number of clicks and completion time (efficiency), and overall satisfaction (Schneidermeier, Hertlein, & Wolff, 2014). Jakob Nielsen, in collaboration with Rolf Molich, developed the 10 Usability Heuristics for User Interface Design in 1990 and was revised in 1995 (Nielsen, 1995). It was a way to guide designers but not necessarily formal usability guidelines or principles.

2.8 Technology in News Media

The use of technology and the web most especially in making news available nowadays, has led to the attention of newsreaders to be diverted away from obtaining information via the traditional means of earlier times, newspapers (Westlund, 2013). News is now consumed on the fly with mobile phones and other mobile devices. Currently, mobile news publishing involves various channels of distribution, from customised SMS or MMS news alerts to mobile news websites and convergent mobile news applications (Westlund, 2013). Most legacy news media organisations now publish content online in addition to the newspapers they publish.

3 Methodology

This section presents and discusses the methods and techniques employed in this study—documentation of the step by step process that led to the final results and research conclusion.

After considering the kind of data to be collected in this research, the choice was made to mostly utilise a quantitative research approach, while employing little qualitative methods. The reasoning behind this decision is to ensure that all types of data relevant for this study are collected and analysed without producing any noticeable weaknesses. Quantitative data and quantitative analysis were performed using questionnaires and statistics. In contrast, Qualitative data was collected from participants comments and questions asked within experiments to obtain the perceptions of participants, and a discussion or breakdown of their responses. Numeric data collected include time taken to complete tasks, time to complete tasks in the experiment, number of errors, and questionnaire answers which were on a numerical scale. These Numeric data were analysed statistically with the help of the statistical software platform SPSS. Statistical analysis was an essential quantitative method used on all the numeric data collected from experiments. Laboratory experiments with students as the user group were used to elicit needed data and discover fundamental patterns through observation. At the start of this research, a detailed literature review provided the opportunity to review previous related works, state of the art, and connect this study to previous studies. It is essential to combine the gains of both a qualitative and quantitative approach to this research. For instance, questionnaires could not capture some issues participants had with the interface of a website prototype, therefore they were only able to indicate these issues such as the brightness or appearance of the interface during the experiment. Some user perceptions can not be quantified; users can only describe such perceptive experiences. Observing users behaviours and choices during the experiments is a feature of a qualitative approach. The experiments used the thinking aloud method introduced to HCI by Clayton Lewis and Robert Mack (Lewis & Mack, 1982). Participants in the experiment were instructed to say what they were thinking, the process they were using and their thoughts about completing tasks.

The approach to the lab experiment, and consequently, the research was a positivist one. Positivism is a scientific research approach that dissects, confirms and predicts theories and hypotheses, mostly in natural and physical sciences (Creswell, 2008). The positivist paradigm mainly makes use of quantitative methods and use of empirical experiments and user groups, rendering pre-experiment and post-experiment tests to determine mean scores (Taylor & Medina, 2011). This research Approach is used in this study because it provides results that are highly valid and reliable (Cohen et al., 2013), and can be generalised to a larger population (Johnson et al., 2004). Other anti-positivist research paradigms were considered. The Interpretive approach would have entailed us using qualitative methods of conducting interviews, creating good relationships, and participant observation. Using this singular approach would only make this study to be based on what participants feel, their subjective opinions and the way the researcher interprets the reasoning of participants. Establishing research solely on the users' personal beliefs can be misleading. Interpretivist research tends to "adapt a relativist ontology in which a single phenomenon may have multiple interpretations rather than a truth that can be determined by the process of measurement" (Pham, 2018). Although this non-positivist research paradigm helps to adequately understand human's thoughts and perceptions, using this approach in this research creates problems due to some of its limitations. A criticism of interpretivism is that its outcomes are inherently subjective rather than objective (Mack, 2010). Thus, research outcomes can be easily influenced by the researcher's perception and interpretation of qualitative data gathered from the responses of people participating in the research experiments. Results cannot be verified through proven numerical measurements, calculations and scientific procedures. This study has also employed a Nomothetic approach in which objective insight is attained through scientific and quantitative methods. The positivist approach was therefore chosen, but with the introduction of some non-positivist or interpretive methods. Non-positivist methods, such as informal questioning and participants' subjective opinions, were included in the research. This research is a hugely positivist one, with a little sprinkle of interpretivism methods.

An experiment was conducted to determine the design approach that provides better usability and is more accessible to a set of visually impaired and non-visually impaired users. Two news website prototypes were designed, one each using the skeuomorphic and flat design approaches. An experiment was developed, including the apparatus and materials needed, and human participants were utilised in interacting with the prototypes to collect data that was analysed.

3.1 Prototyping

A prototype is an early sample of a product, created to allow for user testing and demonstration. The implementation of a workable version of the final product that makes it possible for users and developers to interact with the system and test its functionalities before the design of the end product. There are four types of prototyping models (*Prototyping Model in Software Engineering: Methodology, Process, Approach*, n.d.):

Rapid Throwaway prototyping: this method is used to rapidly create simple prototypes that are then discarded, without undergoing further development stages to produce the final prototype. It is used when instant feedback is needed after a user requirement has been designed.

Evolutionary Prototyping: In this model, the initial prototype is improved upon incrementally as feedback is gotten from users after testing or interacting with previous prototypes. This is helpful in cases where functionalities need to be continuously refined and requirements and continually changing.

Incremental Prototyping: In this model, the main product is disintegrated into several smaller prototypes, and each prototype is refined further on its own, to be eventually combined with other fully developed prototypes, forming the whole final product.

Extreme Prototyping: Extreme Prototyping is a model used mostly for developing web applications, it consists of three (3) phases, where the primary step is where a functional user interface is created, and services simulated.

These prototyping models above show that the process of developing a prototype can either be quite simple or somewhat complex, consisting of multiple revisions. Three (3) stages of developing a prototype, showing the levels of details and refinement are the Low Fidelity prototype, Medium Fidelity prototype, and the High Fidelity prototype. Low fidelity prototypes fast prototypes that may only have a few features of the final product. It can be as simple as a sketch on a paper. Medium fidelity prototypes can demonstrate more functionality than low fidelity prototypes, but they still have some way to go before they look like the final product. A Wireframe is an example of such a prototype; it shows the architectural layout of the product without any visual graphics. The high fidelity prototypes have the appearance of the final product complete with its interface and making it possible for users to interact with it to demonstrate some functionality. As part of this study, designing prototypes was chosen instead of developing full working websites for time and cost reasons. Two prototypes were designed. In the prototyping process, paper sketches like the one shown below were used to create Low fidelity prototypes, while Axure RP 9 was used to develop the final website prototype. Axure RP 9 is a powerful prototyping tool used to plan, prototype and eventually deliver prototypes to developers without the need to code components (*Axure RP 9 - Prototypes, Specifications, and Diagrams in One Tool*, n.d.). It can be used to create interactive web, mobile and desktop prototypes, and provides the possibility of adding code or dragging and dropping. It can also be used for wireframing and documentation. An effort was made to ensure that both prototypes have the same organisation of items. As they are prototypes, the focus was on implementing features that are crucial or related to the tasks, not on developing a complete website with lots of detailed pages.

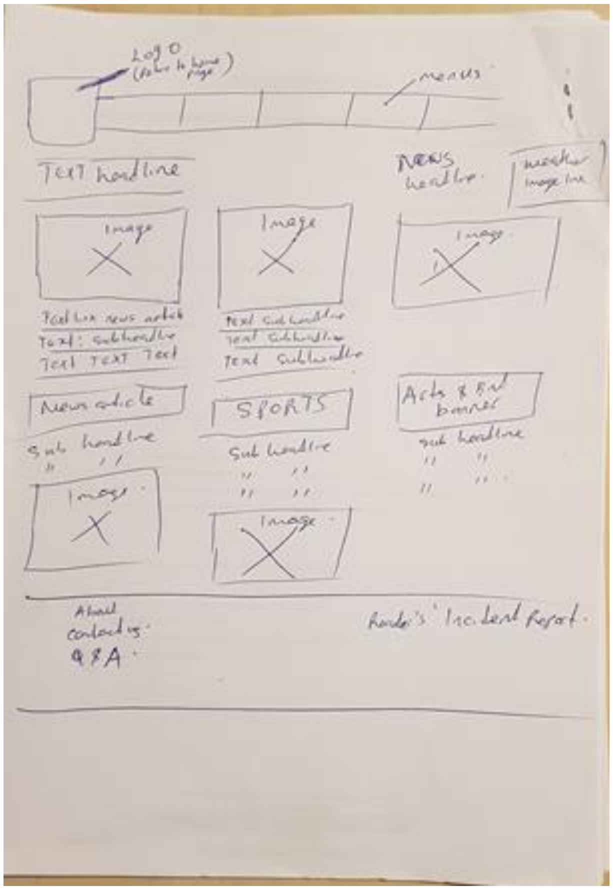


Figure 3-1. *A low fidelity paper sketch prototype of the news website designed for this study.*

The appearance of the website prototypes was created to be representative of real news sites. The headlines, sub-headlines, other text and images are arranged to be similar to the arrangement of contents on CNN's news website. Furthermore, the use and placement of clickable links and pointers (for example, view all>) were done in line with Complete Sport's news website. Webpage contents have been organised into three columns in a newspaper format just like it appears in the CNN homepage shown in Fig 3-2. Headlines come in the largest font, while subheadlines are smaller sized text, and other general news articles are in the smallest sizes, usually below images. These prototypes must not be far off from the kinds of news websites available to people, as anything contrary would make the experiment less realistic to test users and make this study not to be valid with regards to interface designs of news websites.

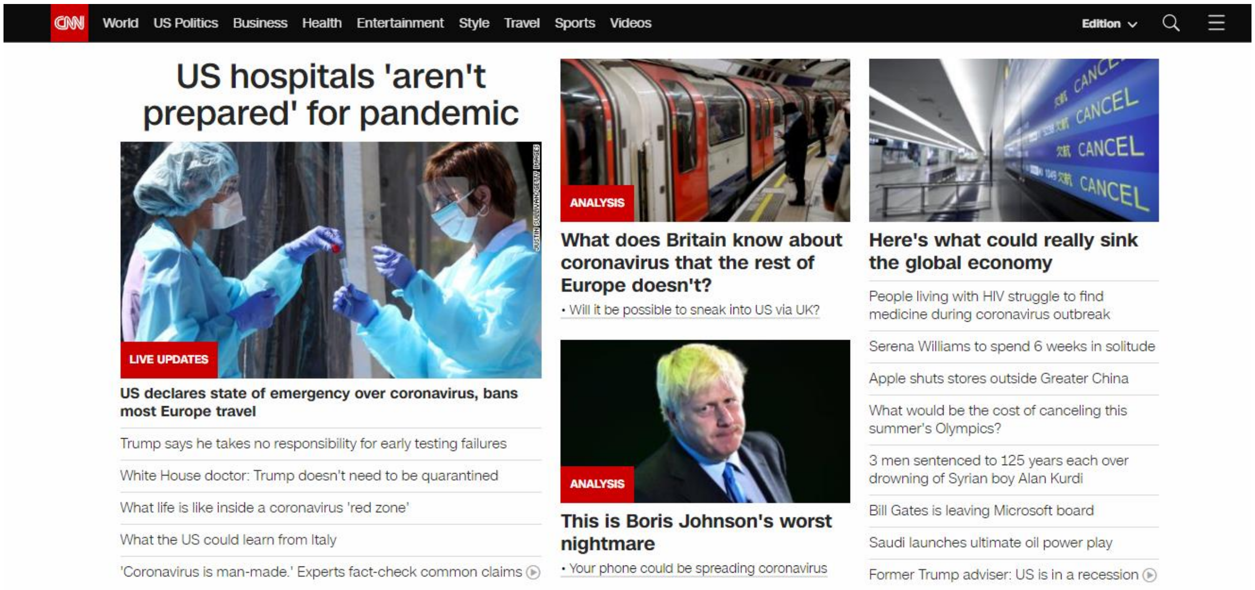


Figure 3-2. *A screengrab of the homepage of CNN's news website.*

3.1.1 Skeuomorphic Prototype

In designing the skeuomorphic website prototype, the effort has been made to utilise adequate affordance, and more real-world depictions to highlight skeuomorphic features. Affordances employed include shadows, changing the contrast on images when they are in focus, use of arrows on some text links to news articles, and linear filling of colour on shapes. Real-world depictions were used in the weather image, sports, latest world news, Reader's incident report, Arts, Entertainment links, the newspaper header banner and the submit button. The affordances are meant to draw more attention to the user to notice that such items are clickable, while the real-world depictions increase the intuitive nature of the information.

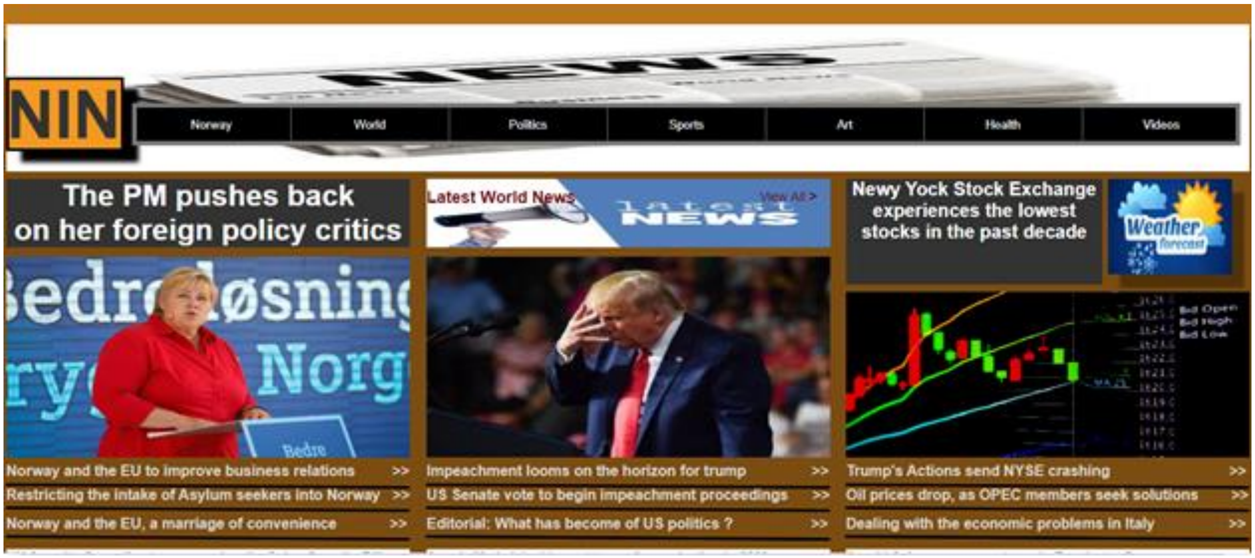


Figure 3-3. *Homepage showing the skeuomorphic designed interface of the news website prototype.*

3.1.2 Flat Prototype

The guiding principles of flat design (Cousins, 2013) were taken into consideration in designing the flat equivalent of the website prototype. Minimalism was central, use of brighter colours, and sans serif font. Images depicting real-world concepts were relaxed into flatter, less shouty images. There were fewer affordances, no shadows, highlights, and bevels.

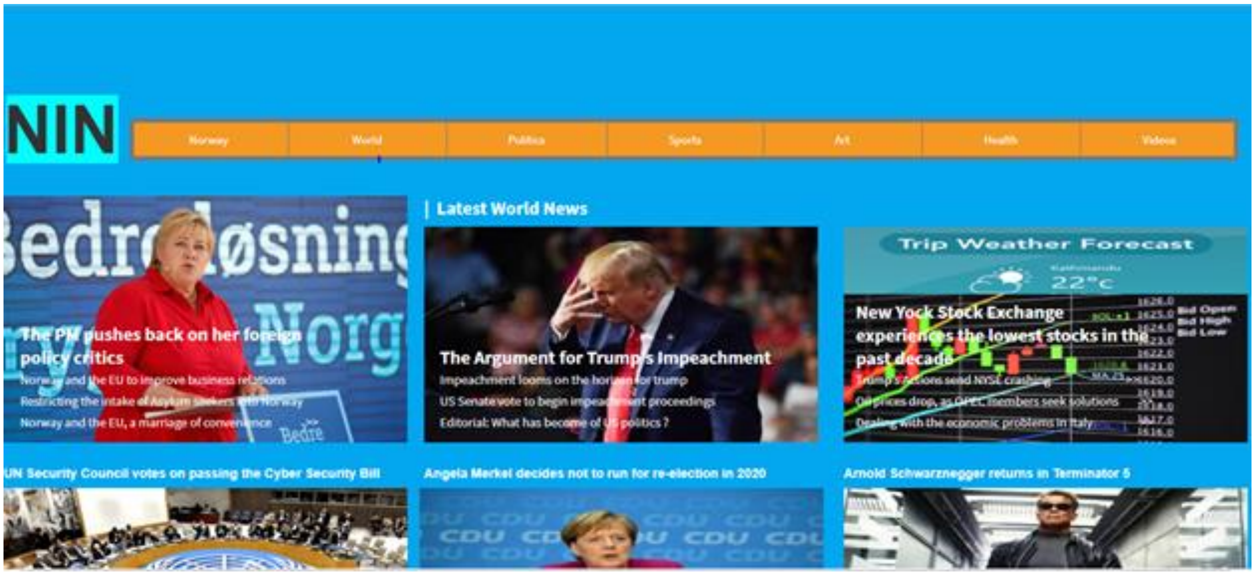


Figure 3-4. *Homepage showing the flat designed interface of the news website prototype.*

3.2 Measuring Usability

According to ISO, usability is measured by the effectiveness, efficiency and satisfaction of users in a given context of use (ISO, 2018). ISO goes on to define each item of measure. Effectiveness is related to accuracy and completeness therefore in our study it can be measured by the task completion rate of a task for a website interface type (also referred to as task success score (Sauro & Lewis, 2012)). In measuring the Effectiveness of users in interacting with Windows 7 (skeuomorphic) and Windows 8 (flat) operating systems, Schneidermeier et al. also considered the number of people that needed help in completing a task (Schneidermeier et al., 2014). Efficiency considers the number of resources used to achieve the desired results. ISO explains that such resources include time, costs, materials and human effort. Efficiency in the context of this study can be measured by considering the time spent on each task, and also the number of steps taken, such as clicks and on-screen movements to complete a task. User satisfaction depends on the perception of a user; this was measured with the use of the post-experiment questionnaire, and a few questions answered verbally during or after the experiment.

3.3 Experiment Design

A laboratory-type experiment was chosen to accommodate the testing of the UIs of the prototypes in a controlled environment and under close supervision, while measurements and observations are documented. The experiment was carried out using a mixed users design. This experimental design type was chosen to allow the use of participants from different demographics in testing and interacting with both skeuomorphic and flat designed interfaces. For example, users with high level IT skills, and those with low level IT skills or users with some form of disability and those without any significant disability. The Mixed design is a combination of experimenting between different classes of users and a within users design where each set of users interact with both UI designs, to get a comparison between them. This also ensures that users in each group are tested against themselves to generate measurements that vary from one user to another.

3.3.1 Hypothesis

In comparing the skeuomorphic interface and flat interface of two news web prototypes and two user groups (visually unimpaired & visually impaired), the following hypotheses were drawn up to guide the evaluation process:

H1: There will be a statistically significant difference between the two interface types in terms of task completion time.

H2: Directly comparing the two user groups, there will be a statistically significant difference between the task completion times of both user groups.

H3: In comparing user groups against the interface type used, there will be a statistical difference in task completion time, depending on the interface used and the user group.

H4: There will be a statistical difference in the ranking of user satisfaction concepts between the user groups concerning interface type.

H5: There will be a statistical difference between both interface types in the ranking of user satisfaction concepts.

H6: The visually impaired (short-sighted) user group will have more positive subjective opinions and perceptions and towards the skeuomorphic interface, while the visually unimpaired group will have more positive perceptions towards the flat interface.

3.3.2 Users

A sample of 20 participants was recruited for the experiment, all of which were university students. All participants possessed good experience and skill in using computers and the internet. They are conversant with surfing the web and reading from news websites. Half (10) of the participants recruited were known to be short-sighted as a form of visual impairment; the other half possessed no visual impairment. Short-sightedness or Myopia is an eye condition that adversely affects a person’s sight, making objects that are distant to be blurred out, sometimes this condition manifests in extreme levels (Starling et al., 2006). The users with this visual impairment were made to participate in experiments without using any visual aids such as prescription lenses or glasses. This is done with the idea that the websites should be easy to use by all without extra assistance, in line with the dictates of universal design. Also, short-sighted people don’t necessarily have their glasses on every time they use the web. All participants had at least five years of experience using the internet for various purposes on computers and smartphones.

3.3.3 Variables

Independent variables are those that the experimenter or facilitator has in control. In the experiment carried out, the independent variables were the skeuomorphic and flat designed user interfaces of the website and app prototypes, and the tasks to be performed by the users. The dependent variables were included performance, and users’ subjective opinions and perceptions. The dependent measures include task completion time, number of errors and participants’ personal views on the usability of the skeuomorphic and flat user interfaces and their ability to identify and recall interface components. Errors occur when a user makes a wrong selection or follows the incorrect process in completing a task. For example, to get to the entertainment and art section of the website, the user clicks on a wrong link—opinions and perceptions of the users elicited by the use of a brief post-experiment usability based questionnaire. The questionnaire was based on a Likert-type scale, in which answer options ranged from 1 to 7, where 7 was the highest positive score that could be chosen as an answer to any question. The experiment focused on aspects of the user interface, such as icons and buttons or clickable items that perform a similar function as a button.

3.3.4 Apparatus and Materials

For the experiment, several apparatus and equipment were used to ensure correct measurements and data is collected. These were:

- A Lenovo laptop with these specifications:
    - Lenovo E31-70 Notebook PC
    - Windows 10 Home 64-bit Operating System
    - Intel(R) Core(™) i3-5005U CPU @ 2.00GHz
    - 8 GB RAM
    - 24inch LG display Screen
- A stopwatch
- Windows GameDVR screen recorder
- pre-experiment questionnaire
- Post experiment questionnaire
- Ethical Consent form
- Information sheet

The experiment was performed in a quiet room at the University, for optimal focus from the participants. Paper materials used in the investigation include a pre-experiment questionnaire, information sheet containing tasks, directions and information about the study, an ethical consent form, post-experiment questionnaire. The pre-experiment questionnaire is used in recruiting experiment participants or users, getting a little sense of their background and their level of competency in using the internet and mobile applications.

The tasks for the flat designed website were the same as those for the skeuomorphic interface prototype. Each user performs the tasks for one prototype and repeats them for the other.

The tasks carried out on the skeuomorphic and flat designed website prototype are listed as:

1. Task 1: Find the link to the news article about internationalisation in Norwegian universities.
2. Task 2: Check the weather and temperature in Oslo.
3. Task 3: Visit the sports section of the website via the sports headline in the body of the home page.
4. Task 4: Visit the sports section of the website via the sports menu.
5. Task 5: After finding and opening the Reader's Incident report, enter a short text and send it.
6. Task 6: Go to the entertainment and arts section of the news.

3.3.5 Procedure

A sample of 20 participants was recruited, all of whom were university students. Fifty per cent of the participants had the short-sighted visual impairment, while the other half had no visual impairment.

The questionnaire sort to elicit information about the participant's background and use of the web. The experiment was carried out for each participant at different dates and times. Each participant took part in the experiment separately; therefore, one user in the room at a time. This was mostly due to scheduling the users according to when they were available for the experiment. A quiet study room at the university was used, and only the facilitator and the participant were present at each time.

On arrival, a participant is welcomed and shown where to sit. The participant then has to read and sign the consent form. The consent form specifies that no personal information will be collected for this study, and that participation is voluntary and can be terminated at any stage of the experiment. The participant then fills out a pre-experiment questionnaire. It contains questions about demographic information, computer and internet competence and experience.

Information describing the experiment and study, including the aim of the study was read from the information sheet and explained to the participant. Other directions on how the experiment was to be performed were clarified. The tasks were then read and understood by the participant. The participant was to perform tasks on the skeuomorphic prototype and then carry out the same functions on the flat designed website prototype. Both website prototypes were similar in the sense that they are both news media websites with the same functionality and components on them but were also different in interface design. During the experiment when participants feel the need to ask questions to know how to go about a task, an effort was made to ensure that they were not assisted in a way that will create a bias. Such a participant was told to "perform the tasks as they are written to the best of your ability". During the experiments things like task times, task completion, errors, and other physical indicators are being recorded.

The participant filled out the post-experiment questionnaire at the end of the tasks. At the end of the experiment and questionnaire, participants were thanked for their time, and given a chocolate bar to show appreciation.

3.3.6 Ethical Considerations

Throughout the recruitment of users, experimenting, and eventual discharge of the users, an effort was made not to collect personal information. No audio or visual recordings of the participants were taken, health information and personal identification were not collected nor stored, names and addresses were not used nor collected. It was not essential to get or use the names of the participants. Furthermore, informed consent was obtained from participants using the consent form and information sheet before they took part in this study. Participants could also choose to opt-out of the experiment at any point in time.

3.4 Post Experiment Questionnaire

These questions were closely related to the tasks the users carried out. They were designed to elicit responses that were in line with the tasks and consequently, in the direction of answering the research questions. Some of the ten usability heuristics of user interface design developed by Jakob Nielsen, which were relevant for this study were also considered in designing these questions. The usability heuristics considered include (*10 Heuristics for User Interface Design: Article by Jakob Nielsen*, n.d.):

- **Visibility of systems status:** The system should always keep users informed about what is going on, through appropriate feedback within a reasonable time.
- **Match between system and the real world:** The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
- **Consistency and standards:** Users should not have to wonder whether different words, situations, or actions mean the same thing.
- **Recognition and recall:** Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for the use of the system should be visible or easily retrievable whenever appropriate.
- **Flexibility and efficiency of use:** Accelerators — unseen by the novice user — may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

It was also essential to ensure that the questions are self-explanatory so that participants are not confused when answering them, and that they can notice the relation of a question to the tasks they have performed. Participants chose answers from a range 1 to 7, where 1 – strongly disagree, 2- disagree, 3 – moderately disagree, 4 -neutral, 5 – moderately agree, 6 – agree, 7 – strongly agree.
The questions are outlined below.

1. Links, buttons and menus were positioned logically and easily located.
2. The contrast and colours used for text, pages and items were appealing and comfortable for viewing.
3. Graphics, depictions, symbols and terms used on the website were intuitive.
4. The appearance and feel of the website, especially the homepage, were appealing.
5. It was easy to find the Reader's incident report form and enter and submit data using the input field and submit button.
6. It is easy to navigate the website without prior knowledge or use.
7. It was easy to distinguish between clickable and non-clickable areas of the website
8. Tasks were easy to complete

4 Results

In displaying the results for each task, task completion times are measured in seconds, and SPSS is used to perform statistical computations of data. Descriptive frequencies are calculated, and normality of data checked in an initial high-level examination of the data collected.

After normality has been determined, a parametric test that suits the kind of distribution being dealt with was chosen. This then led to the decision to use mixed multifactorial ANOVA testing. Mixed multifactorial ANOVA testing "explores mean dependent variable scores across one or more between-group independent variables (with at least two distinct groups) and one or more within-group independent variables (with at least two conditions)" (Mayers, 2013). In cases where the data was hugely not a normal distribution, specifically for the analysis of data collected from the post-experiment questionnaire, the non-parametric Mann-Whitney method (95% confidence) was utilised. Mixed multifactorial ANOVA was used to analyse the data from the tasks, as there was enough normality in the data to use a parametric testing method. The detailed descriptive statistics, normality tests and pairwise comparisons for data from the tasks are detailed in Appendix B. Some tests for normality in task 1 & 2, question 1 & 2 are displayed below. Because the sample size of 20 is small, the Shapiro-Wilk values are reported. Normal data is seen when the probability in the Sig column is greater than or equal to 0.05. In Table 4-1, the data for Flat*Impaired is approaching normality, while other data show normality; therefore, the distribution in task 1 is normal. Most values in the Sig column of the normality test results for data from the questionnaire were below 0.05, take Table 4-3, for example. This, coupled with the used of ordinal data, led to the decision to utilise the non-parametric Mann-Whitney method.

	Visual Capacity	**Shapiro-Wilk**		
		Statistic	df	Sig.
Skeu	Unimpaired	0.977	10	0.949
	Impaired	0.922	10	0.373
Flat	Unimpaired	0.942	10	0.578
	Impaired	0.844	10	0.049

Table 4-1. Test of normality for task 1 data.

	Visual Capacity	**Shapiro-Wilk**		
		Statistic	df	Sig.
Skeu	Unimpaired	0.94	10	0.548
	Impaired	0.897	10	0.205
Flat	Unimpaired	0.911	10	0.286
	Impaired	0.849	10	0.057

Table 4-2. Test of normality for task 2 data.

	Visual Capacity	**Shapiro-Wilk**		
		Statistic	df	Sig.
Skeu	UnImpaired	0.781	10	0.008
	Impaired	0.89	10	0.172
Flat	UnImpaired	0.802	10	0.015
	Impaired	0.833	10	0.036

Table 4-3. Test of normality for question 1 data from the questionnaire.

Task completion time is in seconds, and tasks were performed on skeuomorphic and flat interfaces. Participants are divided into two user groups based on their ‘visual capacity’. Visual capacity 1 indicates a visually unimpaired user, while visual capacity 2 represents a visually impaired short-sighted user.

4.1 Quantitative Results

This section presents the results of statistical computation and analysis of data collected from user experiments. Data was collected from the tasks conducted in the experiments and the post-experiment questionnaire.

4.1.1 Task 1

In the first task, users are asked to scan the website prototype and find a link to a news article titled Internationalisation in Norwegian Universities.

	Visual Capacity	Mean	Std. Deviation	N
Skeu	Unimpaired	10.3370	1.61311	10
	Impaired	10.8870	1.45173	10
	Total	10.6120	1.52003	20
Flat	Unimpaired	11.7960	3.80813	10
	Impaired	9.6510	2.07268	10
	Total	10.7235	3.18042	20

Table 4-4. Descriptive statistics of task 1 data

After Applying Mixed multifactorial ANOVA testing on the data, it could be prematurely deduced from the means that; the visually impaired users performed Task 1 slightly faster than their counterpart with mean times of 10.269 and 11.067 respectively. However, there was no statistical difference in the times posted across the two groups $F(1,18) = 1.438$, $p = 0.246$. There was no statistical difference in the mean task time spent across the skeuomorphic interface and the flat interface, with mean task times of 10.612 and 10.724 respectively, $F(1,18) = 0.017$, $p = 0.898$.

There was no statistical significance in the pairwise comparisons of task completion times between Interface types (skeuomorphic & flat), between visual capacity groups (impaired & unimpaired), and also between the mix of the interface and visual capacity groups $F(1,18) = 2.477$, $p = 0.133$.

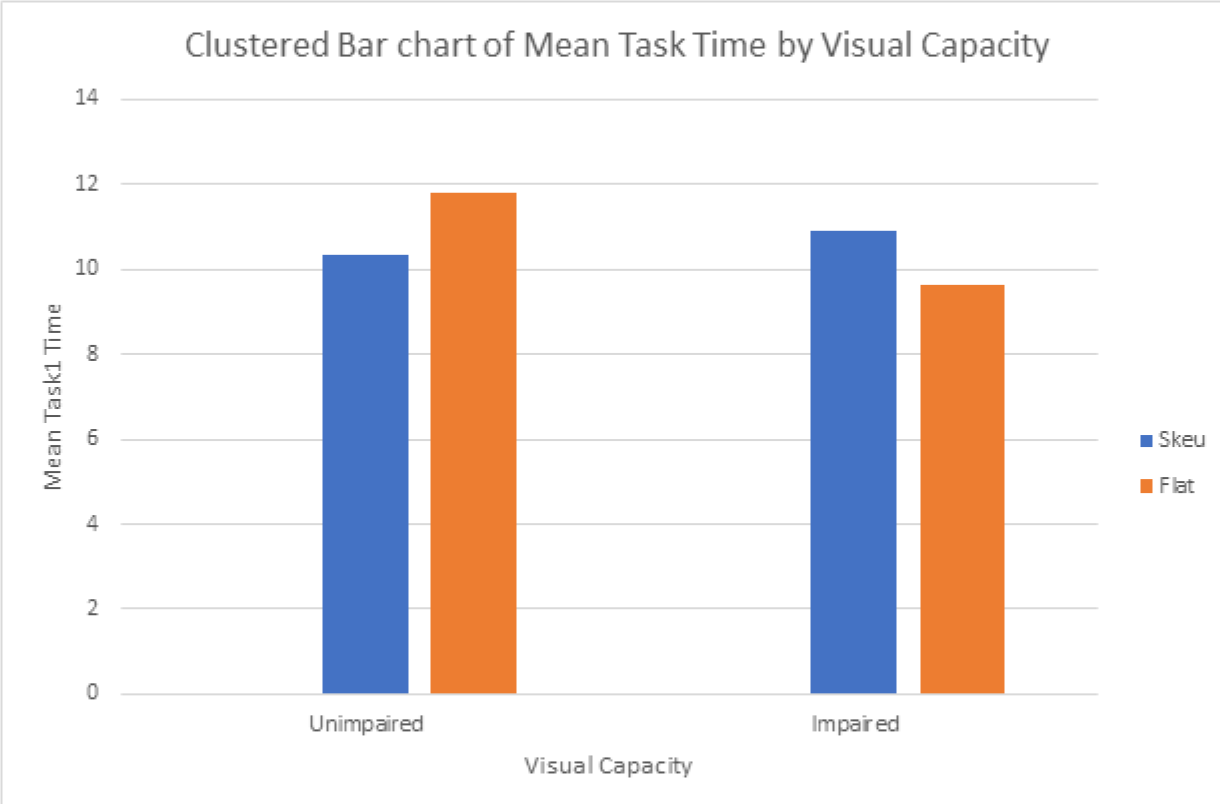


Figure 4-1*. Clustered bar chat of mean task completion time by user groups (visual capacity) for Task 1.*

4.1.2 Task 2

Users are told to locate and view the weather and temperature in Oslo. This had to be done by finding the weather graphic link.

There was no statistical significance in mean task time between unimpaired users, 8.043, and visually impaired users, 5.534, F (1,18) = 3.524, p = 0.077. The same occurred for the mean task times grouped by interface type, where task 2 was completed a bit faster for the skeuomorphic interface, (mean time 6.266) than the flat interface (mean 7.311), F(1,18) = 1.532 p = 0.232.

	Visual Capacity	Shapiro-Wilk		
		Statistic	df	Sig.
Skeu	Unimpaired	0.94	10	0.548
	Impaired	0.897	10	0.205
Flat	Unimpaired	0.911	10	0.286
	Impaired	0.849	10	0.057

Table 4-5. Descriptive statistics for task 2 data.

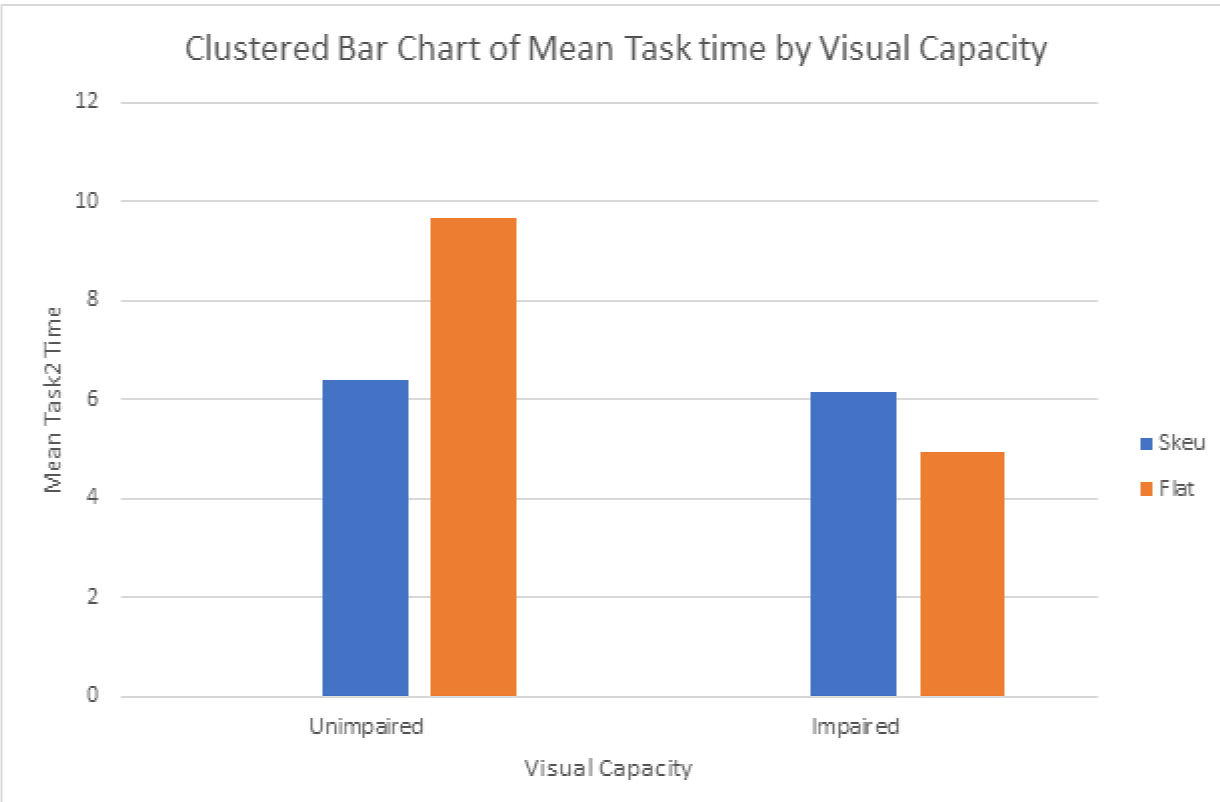


Figure 4-2. *Clustered bar chat of mean task completion time by user groups (visual capacity) for Task 2.*

However, the results showed there is a statistical significance in the test of within-subject contrast between interface type and visual capacity, $F(1,18) = 7.129$ $p = 0.016$. An initial look at the data elicited from the pairwise comparison of visual capacity against interface type shows that unimpaired users spent more time to complete Task 2 in both interfaces than the impaired users. Post hoc tests were carried out on the data; two t-tests on the task completion times based on Interface type, and two repeated-measures one-way ANOVA tests across two visual capacity groups, using the split file facility in SPSS. Results from the t-test shows that there is no significant difference in task completion times in relation to the skeuomorphic interface, $t(18) = 0.205$, $p > 0.025$, but there is a statistical significance in the task completion times for the flat interface, $t(18) = 2.561$, $p = 0.020$. The repeated-measures one-way ANOVA test showed no significant difference in task completion times by interface type according to visual capacity. Unimpaired*Interface; $F(1,9) = 4.241$, $p > 0.025$, Impaired*Interface; $F(1,9) = 5.140$, $p = 0.050$. It can be deduced that the task completion time using the Flat interface is significantly higher with the unimpaired users (Mean = 9.69) than the impaired users (Mean = 4.93).

4.1.3 Task 3

Users are to visit the sports page of the website via the sports headline link in the homepage.

Results showed no statistically significant difference in the mean task completion times concerning interface types, where the task was completed faster on the flat interface (Mean = 9.8360) than the skeuomorphic interface (Mean = 8.9785), $F(1,18) = 0.943$, $p = 0.344$.

Subsequently, Mean task completion times according to visual capacity also showed no statistical difference to back up the lesser Mean time used by visually impaired users, 8.595, in comparison to the mean task completion time of the visually unimpaired users, 10.220; $F(1,18) = 3.874$ $p = 0.065$. Furthermore, the contrasts between interface type and visual capacity elicited no statistical significance, $F(1,18) = 0.585$, $p = 0.454$.

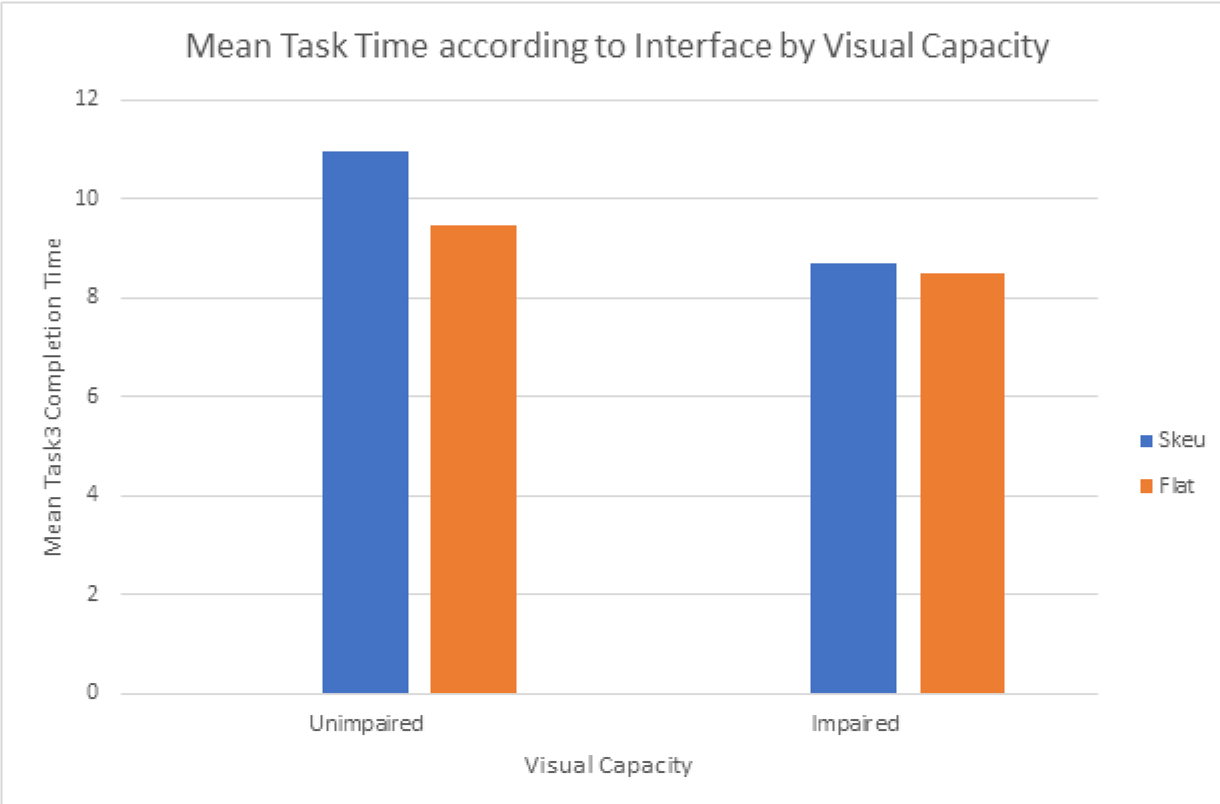


***Figure 4-3**. A Clustered bar chat of mean task completion time by user groups (visual capacity) for Task 3.*

4.1.4 Task 4

In Task 4, users visited the sports section of the website via the sports menu on the menu bar.

Task 4 produced no statistical significance in the difference between Mean task completion times across the interface types, with mean task times (skeu = 3.904, flat = 3.888); $F(1,18) = 0.004$ $p = 0.952$. This was the same case in the contrast between visual capacity groups, with Mean task times (unimp = 4.058, imp = 3.733); $F(1,18) = 0.712$ $p = 0.410$. The pairwise comparisons between visual capacity groups and interface types show that the visually impaired user completed the task quicker than the visually unimpaired users with both interface types, and all together. It was however not statistically significant, $F(1,18) = 0.305$ $p = 0.588$.

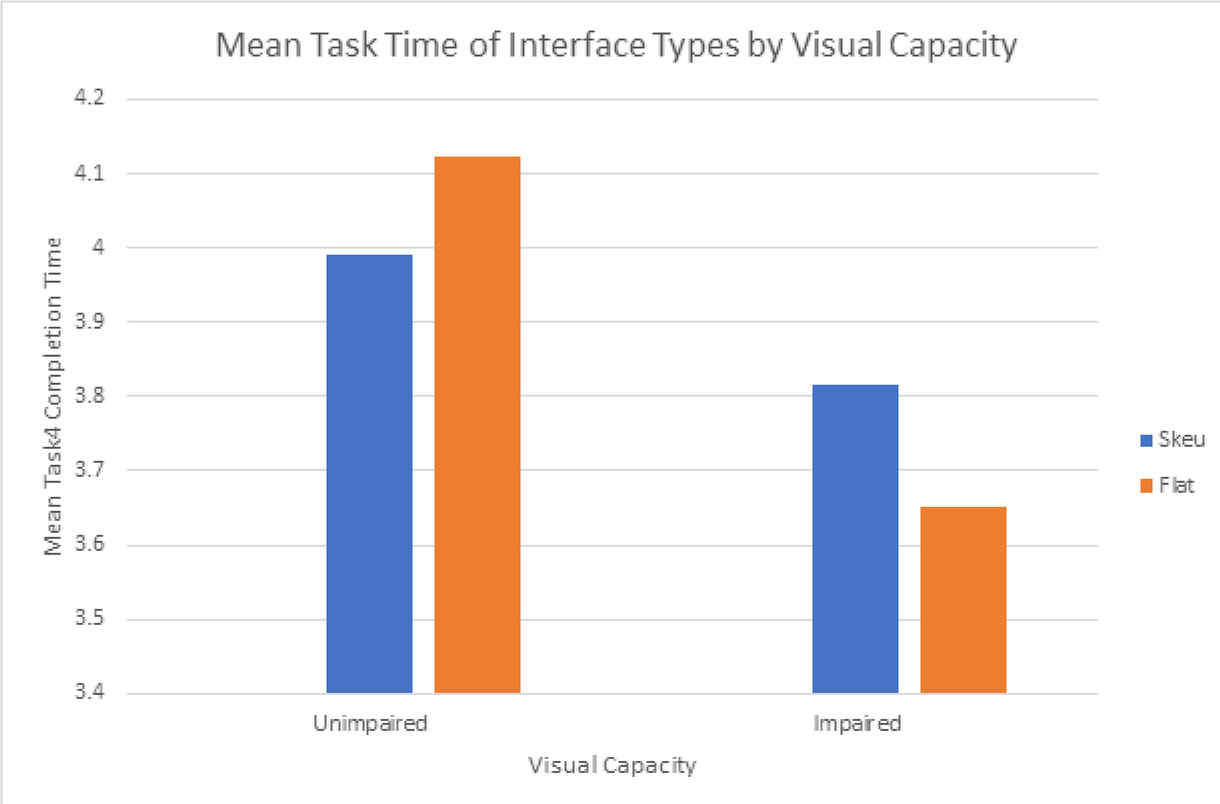


Figure 4-4. *A Clustered bar chat of mean task completion time by user groups (visual capacity) for Task 4.*

4.1.5 Task 5

In finding and writing text into the reader's incident report on the news web prototypes, the skeuomorphic interface allowed for a quicker completion time than the flat interface, albeit with no statistical difference, Mean task completion times = (18.5465, 20.5760), $F(1,18) = 0.673$ $p = 0.423$. There was also no statistical difference to back up the data that showed the visually impaired users completing the task a little bit faster than their counterparts irrespective of the interface type, (Mean = 20.103, 19.02); $F(1,18) = 0.103$ $p = 0.752$. The Mixed multifactorial ANOVA tests of within-subjects contrast between interface types and visual capacity showed no statistical significance; $F(1,18) = 3.802$ $p = 0.067$, with the visually unimpaired users performing the task quicker than their counterparts using the skeuomorphic interface, but slower using the flat interface. Further post hoc t-test and repeated measures one-way ANOVA test showed no statistically significant results.

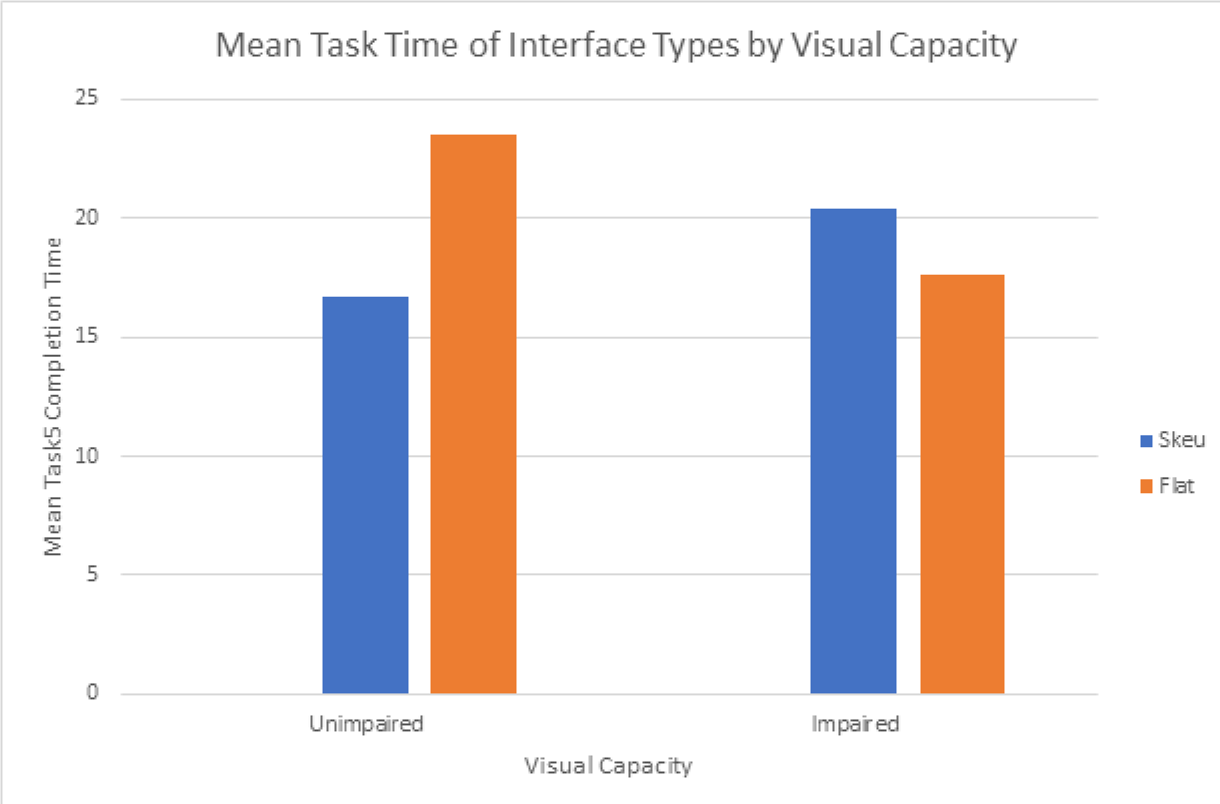


Figure 4-5. *A Clustered bar chat of mean task completion time by user groups (visual capacity) for Task 5.*

4.1.6 Task 6

In locating and clicking on the entertainment and arts section of the news website prototypes, less mean task completion time was spent to complete the task using the flat interface than with the skeuomorphic interface, however it was not a statistically significant result, Mean = (7.1195, 8.2230), $F(1,18) = 3.615$ $p = 0.073$. Solely considering visual capacity, there was no statistical significance with the result showing the visually unimpaired users completing the task slightly quicker than their counterparts, Mean = (7.380, 7.962), $F(1,18) = 0.408$ $p = 0.531$. Test of within-subject effects contrasting between interface type and visual capacity shows that the visually unimpaired users performed the task slightly quicker than their counterparts in both interface types. Furthermore, the flat interface allowed for lesser completion time for both user groups; however, both contrasts resulted in no statistical significance, $F(1,18) = 0.295$ $p = 0.593$.

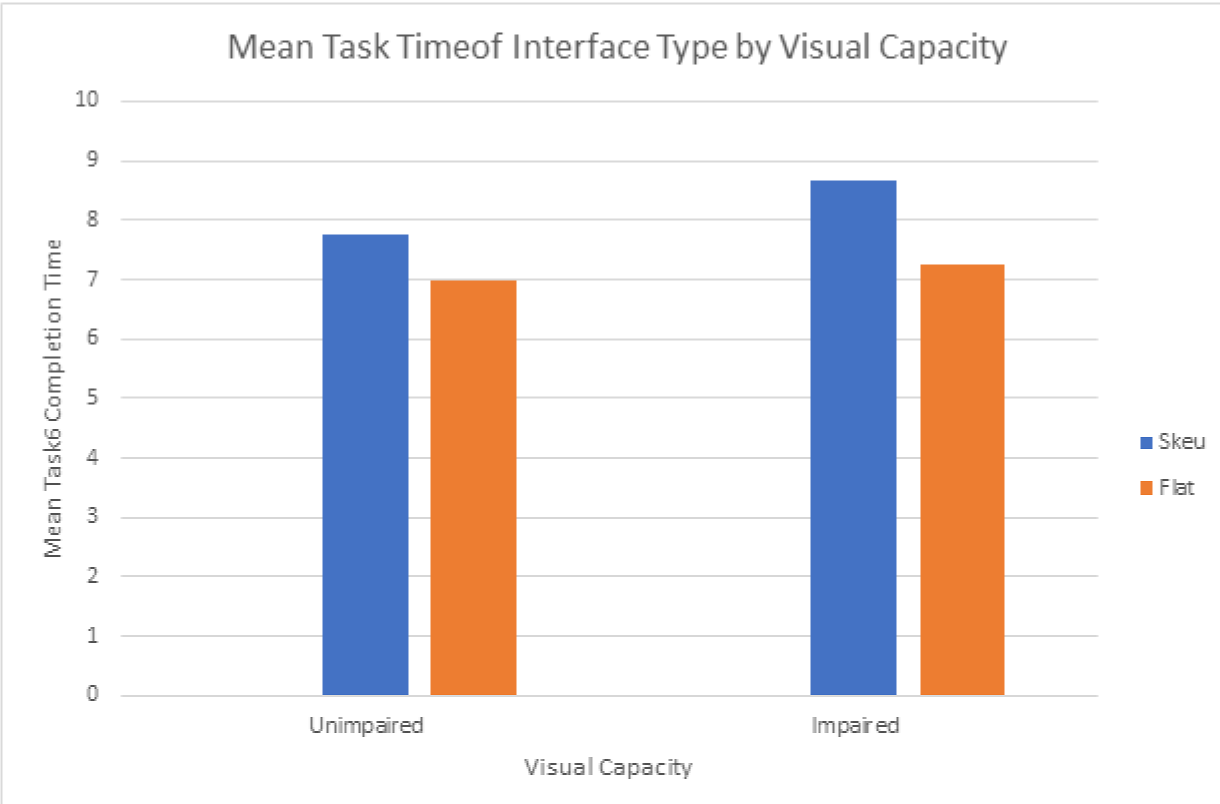


Figure 4-6. *A Clustered bar chat of mean task completion time by user groups (visual capacity) for Task 6.*

4.1.7 Question 1

The post-experiment questionnaire is made up of 8 questions, each answered on a Likert 7 line scale, where 1 – strongly disagree, 2- disagree, 3 – moderately disagree, 4 -neutral, 5 – moderately agree, 6 – agree, 7 – strongly disagree. These were represented as an ordinal measure in SPSS computations. Tests for normality performed on the data collected from the questionnaires showed that all data were not entirely normally distributed and considering ordinal data type, non-parametric Mann-Whitney U test was applied to data elicited via the post-experiment questionnaire.

The first question asked how true it is that links, buttons and menus were easily located. For this question, visually impaired users provided higher scores for the flat interface (MD = 6.10), and the visually unimpaired users provided higher scores for the skeuomorphic interface (MD = 5.5) when both groups were asked if links, buttons and menus were positioned logically and easily located. However, there was no statistical difference between the visually unimpaired and visually impaired user groups, for the skeuomorphic interface: $U = 43$, $MD_{unim} = 5.5$, $MD_{imp} = 5.0$, $p = 0.631$, $r = 0.129$, and the flat interface: $U = 42$, $MD_{unim} = 6.0$, $MD_{imp} = 6.10$, $p = 0.579$, $r = 0.139$.

When the Wilcox signed-rank test was applied on the complete user sample to make comparisons between skeuomorphic and flat designed interfaces, the result showed a statistical significance, with the flat interface scoring better than the skeuomorphic interface ($MD_{flat} = 6.0$, $MD_{skeu} = 5.0$); $W = 22.5$; $p = 0.006$; $r = 0.612$. Hence the results show that the combined user groups felt that links, buttons and menus were positioned logically and easier to find on the flat designed web interface.

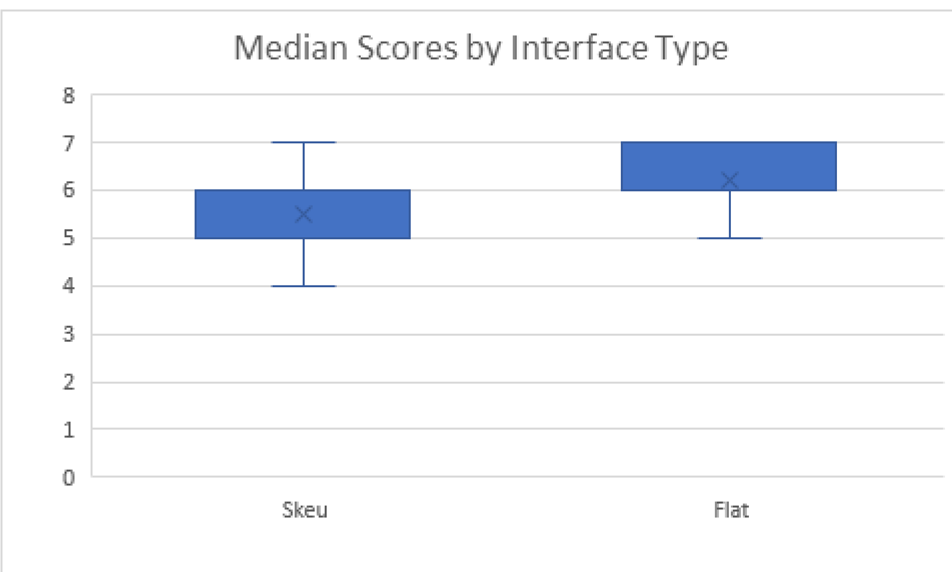


Figure 4-7. *A box plot of the median scores or ratings for question 1 according to the type of interface design.*

4.1.8 Question 2

Question 2 asked how appealing and comfortable for viewing was the contrast and colours used for text, pages and other web items.

Using the Mann-Whitney method (95% confidence), the result showed there was a statistical significance for the skeuomorphic interface, where the interface is scored to have more appealing and comfortable colour and contrast for the visually unimpaired users (MD = 6.0) than the visually impaired users (MD = 4.0), U = 17; p = 0.011, r = 0.573. There was no statistical significance in the comparison between the two user groups regarding the flat interface, (MDunimp = 6.0, MDimp = 6.5); p = 0.218, r = 0.296.

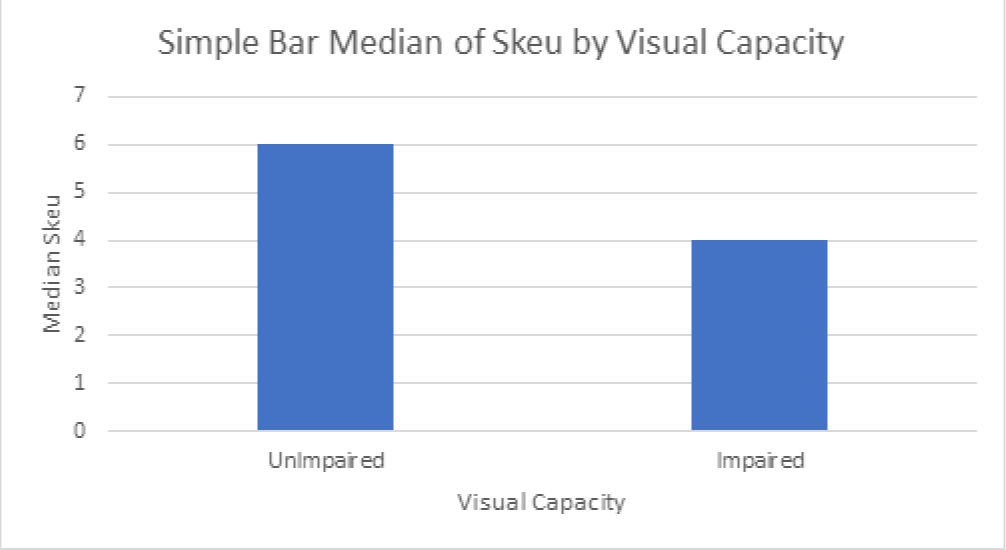


Figure 4-8*. A bar chart of the median scores of the skeuomorphic interface by visual capacity for question 2.*

The result of the Wilcox signed-rank test on the complete user sample showed a statistical difference between both interface types, where the flat interface (MD = 6.0) scored higher than the skeuomorphic interface (MD = 5.0); W = 30; p = 0.007; r = 0.600.

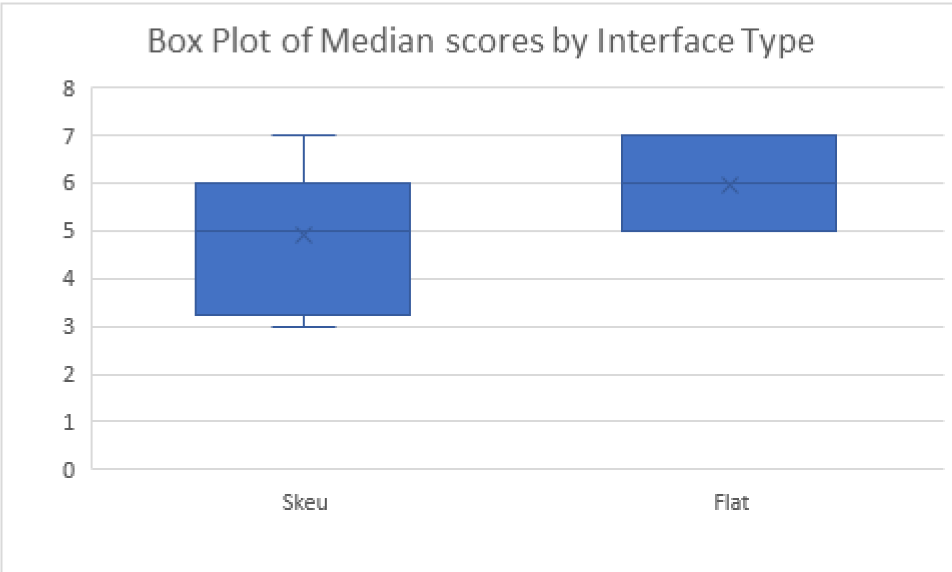


Figure 4-9*. A box plot of the median scores of question 2 according to the type of interface design.*

4.1.9 Question 3

Regarding the intuitiveness of graphics, depictions, symbols and terms, results showed no statistical significance when Mann-Whitney U test is applied to compare the scores from the two user groups for both the skeuomorphic interface (MDunim = 5.5, MDimp = 5.0); U = 49.0; p = 0.971; r = 0.018, and the Flat interface (MDunim = 6.0, MDimp = 6.0); U = 44.0; p = 0.648, r = 0.107.

The results of the Wilcox signed-rank test on the combined user sample showed a statistical significance in the flat interface scoring better with regards to intuitiveness (MDskeu = 5.0, MDflat = 6.0); W = 11.0; p = 0.019; r = 0.526.

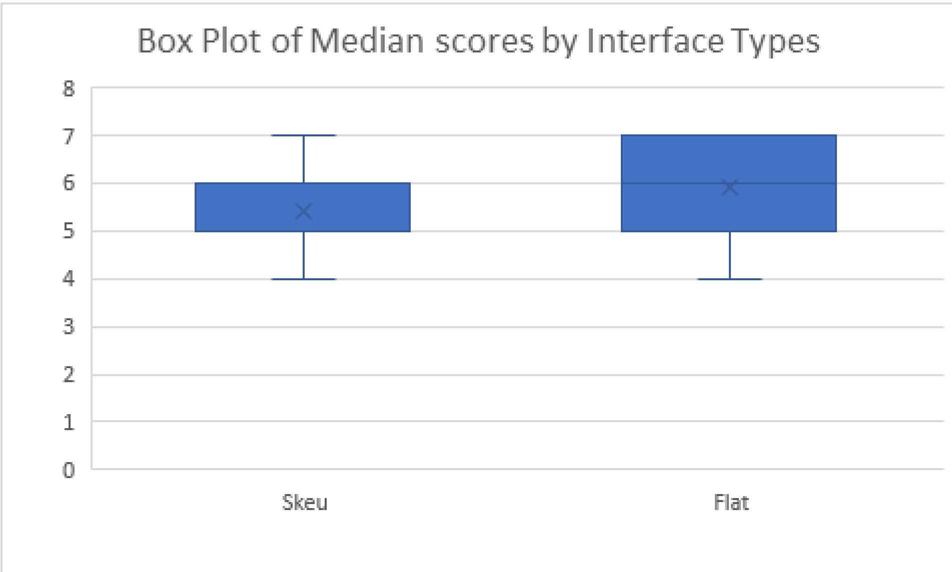


***Figure 4-10**. A box plot of the median scores of question 3 according to the type of interface design.*

4.1.10 Question 4

Regarding the appearance and feel of the website, especially its homepage, the results showed no statistical significance when Mann-Whitney U test is applied to compare the scores from the two user groups for both the skeuomorphic interface (MDunim = 5.0, MDimp = 5.0); U = 49.0; p = 0.971; r = 0.018, and the Flat interface (MDunim = 5.0, MDimp = 5.0); U = 47.0; p = 0.853, r = 0.052.

The results of the Wilcox signed-rank test on the combined user sample showed no statistical difference between the scores for both interfaces (MDskeu = 5.0, MDflat = 5.0); W = 82.0; p = 0.874; r = 0.035.

4.1.11 Question 5

Question 5 inquired about the ease of finding the reader's incident report form and using it to submit data.

The result of the Mann-Whitney U test showed a statistical significance. It hinted that visually impaired users find it easier to locate and use the reader's incident report form using the skeuomorphic interface than their counterparts, (MDunim = 5.0, MDimp = 6.0); U = 23.0; p = 0.043; r = 0.474.

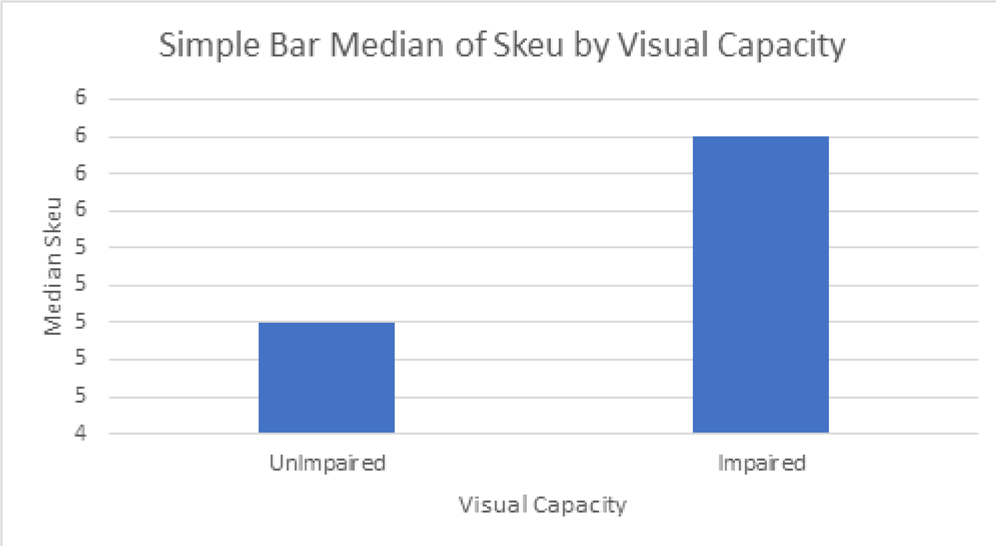


Figure 4-11*. A bar chart of the median scores of the skeuomorphic interface by visual capacity for question 5.*

There was no statistical significance to back up the slightly higher scores by visually impaired users for the flat interface; (MDunim = 6.0, MDimp = 6.5), U = 41.0; p = 0.529; r = 0.160.

The results of the Wilcox signed-rank test on the combined user sample showed a statistical significance, with the flat interface rated to make it more easier to find and use the reader's incident report: (MDskeu = 5.0, MDflat = 6.0); W = 5.0; p = 0.005; r = 0.627.

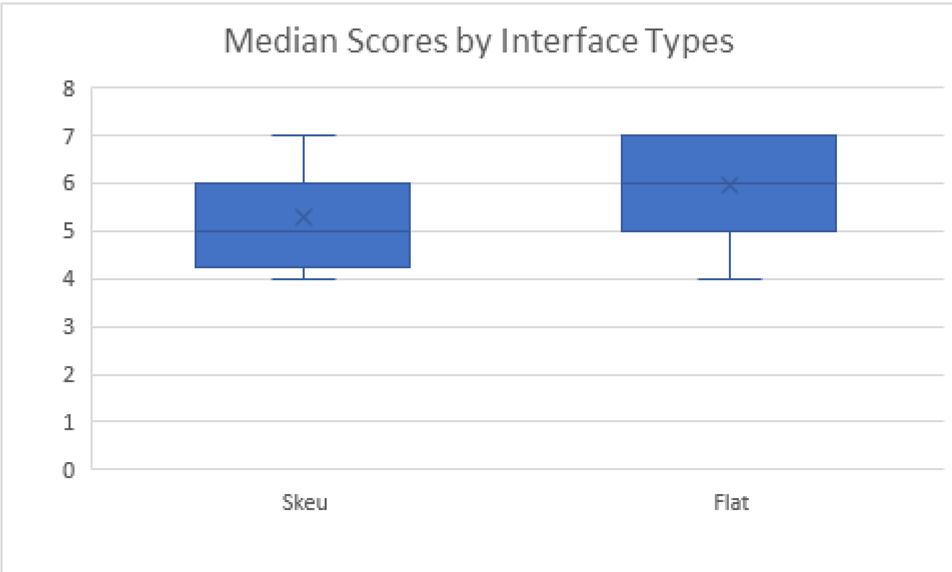


Figure 4-12*. A box plot of the median scores of question 5 according to the type of interface design.*

4.1.12 Question 6

Regarding the ease of navigation on a web interface without prior knowledge or use, the results showed no statistical significance when Mann-Whitney U test is applied to compare the scores from the two user groups for both the skeuomorphic interface (MDunim = 6.0, MDimp = 6.0); U = 38.0; p = 0.393; r = 0.216, and the Flat interface (MDunim = 6.0, MDimp = 6.0); U = 28.0; p = 0.105, r = 0.404.

The results of the Wilcox signed-rank test on the combined user sample showed no statistical difference between the scores for both interfaces (MDskeu = 6.0, MDflat = 6.0); W = 8.0; p = 0.257; r = 0.253.

4.1.13 Question 7

This question inquired about the ease of differentiating between clickable and unclickable parts of the website prototypes. After applying the Mann-Whitney U test no statistical significance was found to back up the data concerning scores given. The result for the skeuomorphic interface; (MDunim = 5.0, MDimp = 5.5); U = 41.5; p =

0.529; r = 0.151, and the Flat interface (MDunim = 6.0, MDimp = 6.0); U = 34.0; p = 0.247, r = 0.291.

The results of the Wilcox signed-rank test on the combined user sample showed no statistical difference between the scores for both interfaces (MDskeu = 5.0, MDflat = 5.5); W = 49.0; p = 0.808; r = 0.054.

4.1.14 Question 8

Question 8 elicited scores or ranks regarding the ease of completing tasks during the experiment. The result of the Mann-Whitney U test showed a statistical significance. It hinted that visually impaired users found it easier to complete the tasks in the experiment than their counterparts when using the skeuomorphic interface: (MDunim = 6.0, MDimp = 7.0); U = 21.0; p = 0.029; r = 0.520.

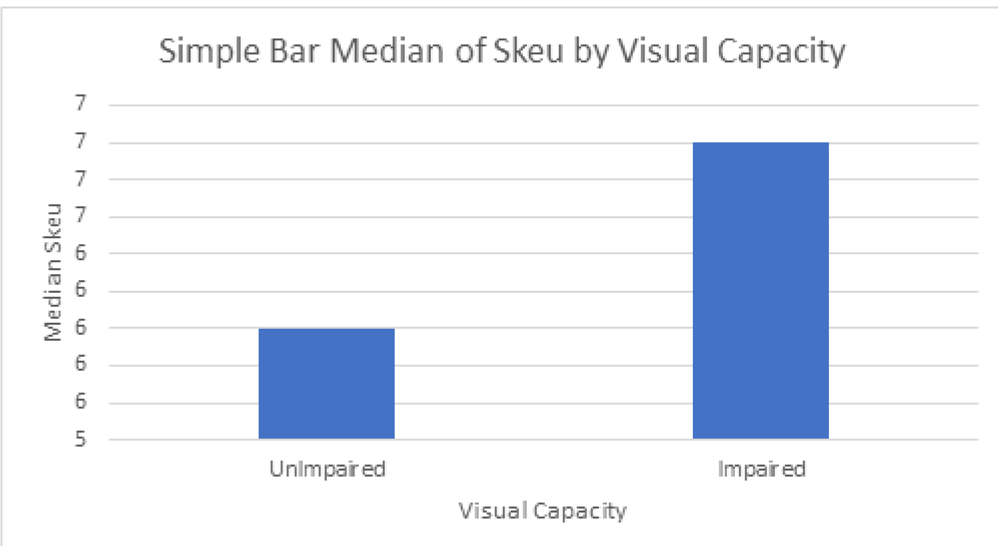


Figure 4-13*. A bar chart of the median scores of the skeuomorphic interface by visual capacity for question 8.*

There was no statistical significance in comparing the scores of each user group with respect to the flat interface; (MDunim = 6.0, MDimp = 6.0), U = 44.0; p = 0.684; r = 0.109.

The results of the Wilcox signed-rank test on the combined user sample showed no statistical difference between the scores for both interfaces (MDskeu = 6.0, MDflat = 6.0); W = 25.0; p = 0.366; r = 0.202.

4.2 Qualitative Results

In this section, the results of the subjective opinions of participants in the user experiment are put together. Users were advised to make comments and think aloud while carrying out tasks and answering the post-experiment questionnaire. They were also questioned informally about reasons surrounding some of their choices.

In reference to the intuitiveness of Graphics, depictions and terms on the website prototypes, a visually unimpaired user stated that items on both websites were easy to visualise, but that the website with the flat interface was a little bit easier. The user was also of the opinion that the submit button and the reader's incident report icon/graphic looked a bit small on the skeuomorphic interface, but that it was easy and clear to read the text on the icon on the flat interface. Another visually unimpaired user emphasised his preference for the contrast of the flat interface.

A visually impaired user opined that the skeuomorphic interface has low contrast but good colours, while the flat interface has better contrast but unappealing colours. Another visually impaired thought that it was easier to look at images or graphics on the flat interface. The same user regarding the fifth question in the post-experiment questionnaire stated that the incident text on the image or icon was clear to see in both interface types, also such incident report forms are usually put at the bottom of the web page. The user went on to note that having graphics/images change contrast when the cursor is hovering over it made it easy to know that such a graphic could be clicked on to visit a different web page.

Many users believed that navigating both web prototypes without prior use was not a problem because it had the organisation of traditional news websites which they are accustomed to.

5 Discussion

UI design has over the years been dominated by two main approaches, skeuomorphism and flat design, with some merging characteristics of both styles. This study has investigated the usability and universality of these two design approaches in direct relation to news websites. User experiments performed have been able to explore these design approaches and test hypotheses on task completion time, item recognition, and general usability regarding interface design type and user group. The diversity of the user sample, which classified the users into two groups based on their visual capabilities was done in a bid to test the acceptability of the web interfaces to any user irrespective of impairment. This section discusses the results of the experiment and research in brevity while checking if hypotheses were accepted or rejected. The strengths and weaknesses of this study are also explained.

5.1 Evaluating Hypotheses

In comparing the performance of the two interface designs of the web prototypes, results of task completion time for all six tasks showed no statistically significant difference. Hence the first hypothesis which states that there will be a statistically significant difference between the two interface types in terms of task completion time is rejected. In task 3 and 5, the skeuomorphic interface seemed to generate some tangible level of quicker mean task completion time. However, this did not lead to any statistical significance. Same also in task 6, where the flat interface posted a bit shorter task completion time with no statistical significance. This means that user interface design approach did not affect performance in terms of how fast a user can find information or items and use the news website in general. It is not clear why there was no statistical significance in the comparisons above as one would have expected the difference in interface type to affect task completion time. It could be that similarity in the placement or organisation of items on both web prototypes makes it faster to complete a task on the second prototype than the first for all users. This is because they already have an idea of where the item is located from carrying out the task in the first web prototype.

To ensure that a product is universally designed, it must be flexible enough to provide the same type of service and usability to different kinds of users irrespective of their characteristics and impairments. The second hypothesis predicted a statistical difference in the performance of the visually unimpaired users against the short-sighted visually impaired users, regardless of the user interface type used. It could be seen that the mean task completion times between the user groups in task 2 and 3 shows a significant nominal difference. However, statistical analysis showed that the results in all the tasks were not statistically significant. Therefore this hypothesis was rejected. The visual impairment short-sightedness was predicted to be a defining factor for performance. Still, it turned out not to be so in this experiment, at least when both user groups are put head to head irrespective of interface type used. The short-sighted users did not make use of medically prescribed lenses that help correct their vision. It is not clear if this was a determining factor.

During statistical analysis, pairwise comparisons of within-subject effects were made between the user groups and the web interface types. Just one out of the six tasks performed had a statistically significant result concerning the pairwise comparisons. This was in task 2, where users were asked to visit the weather forecast page to see the weather forecast for Oslo. The result of this task showed that the visually impaired users completed the task quicker than the visually unimpaired users when using the web prototype with a flat interface. The third hypothesis is only partially accepted as only one task showed a statistically significant difference in pairwise comparisons between user groups and web interface type.

Further investigation into usability and user satisfaction were made using the post-experiment questionnaire. Users ranked or scored each question on a Likert scale of 1 to 7, with 1 being the lowest and 7 being the highest or most positive answer. Quantitative analysis of the data in ranking user satisfaction between the two user groups concerning the interface type used showed statistically significant results in three (3) questions. Thus, the fourth hypothesis is partially accepted. In rating the contrast and colours of text, webpages, web contents and how appealing they are, there

was a statistically significant result; the visually unimpaired users rated the skeuomorphic interface higher than the visually impaired user group. This hints that the general feel and aesthetics of the skeuomorphic interface is less acceptable to the short-sighted visually impaired user group. This is corroborated in the result from the first question about the logical positioning and location of webpage items, albeit there was on statistical significance; where the visually unimpaired users rated the skeuomorphic interface higher than their counterparts, and the visually impaired users rated the flat interface higher than the visually unimpaired users.
They were further hinting that the visually impaired users may better appreciate the flat interface news website. However, this was countered by the statistically significant result from the fifth question about the ease of finding the reader's incident report and submitting a short incident report. Here the visually impaired users rated the skeuomorphic interface higher than the visually unimpaired user group. Furthermore, in question 8, the statistically significant result showed that visually impaired users felt it was easier to complete tasks with the skeuomorphic interface than the visually unimpaired users.

Comparison between both interface types based on users' satisfaction and usability concepts elicited statistically significant results in four (4) out of the eight questions. Therefore, the fifth hypothesis is partially accepted. The hypothesis states that there will be a statistical difference between both interface types in the ranking of user satisfaction concepts. Note that all 20 users are looked at as a whole, without division into user groups in this comparison between interface types. In the statistically significant results, the flat designed news web prototype dominated by being rated higher than the skeuomorphic option by the users. This was a telling result that hints that the combined user sample tend to be more satisfied with the usability of the flat interface. It has previously been established in the literature review that more and more websites are being designed with a flat interface, results like this may continue to enhance that trend.

Qualitatively analysing the comments from users during the experiment; one could see that most opinions of the visually impaired users were more positive towards the flat interface. This means that the sixth hypothesis is rejected. The hypothesis states that the visually impaired (short-sighted) user group will have more positive subjective opinions and perceptions and towards the skeuomorphic interface. In contrast, the visually unimpaired group will have more positive perceptions of the flat interface. This hypothesis was formulated with an educated guess that short-sighted users will prefer more affordance and elevation of items on a web page, as this will make such things look nearer and emphasise their features better for them to visualise easily.

Results showed that UI design type mostly did not affect tax execution duration, which is similar to the results of the work done by Spiliotopoulos et. Al (Spiliotopoulos, Rigou, & Sirmakessis, 2018), which investigated the two prominent design trends on at the level of icon design on websites. Unlike results in (Urbano et al., 2020) which showed that users were slower with flat interface in comparison to the skeuomorphic interface. However, the age of the users played a significant role in producing this difference, as older users performed tasks significantly slower on the flat interface (Urbano et al., 2020). The post-experiment questionnaire which accesses usability and quality of a design rated the flat design higher than the skeuomorphic approach in a similar way as in the results of the SUS questionnaire used in (Spiliotopoulos, Rigou, & Sirmakessis, 2018). However, usability and user satisfaction results based on visual capacity were inconclusive. Several studies have investigated how the age group and skill set of users have affected the way they use interfaces with skeuomorphic and flat designs. This research study is valuable in that it has investigated user groups based on visual capacity. It is pertinent to understand how interface designs affect the way people use technology, as the world inches closer to making technology accessible to all. Utilising users with a visual impairment, in this case, short-sightedness strengthened the universal design theme of the study. It was also beneficial to create a usability questionnaire that is tailor-made for this research and technology. Only utilising the standard SUS questionnaire does not suffice. Results of this study are a significant pointer to how UIs of websites, especially news websites, should be designed to cater for short-sighted visually impaired users. More research focused on including people living with impairments in the conversation of technological advancements are needed.

It is essential to be cautious and wary of generalising the findings of this research for various reasons; the sample size of the users in the experiment can be expanded upon, and this was specific research. One should not generalise the results for any visually impaired user group as this study only made users with a short-sighted visual impairment. It must also be noted that a case study of a news website was studied. Hence the results may differ for an application or an e-commerce website.

5.2 Limitations

There are some weak points in this study that can be improved upon. The user sample size of 20; 10 visually unimpaired users and ten visually impaired short-sighted users, may not be adequate to draw up comprehensive and definite conclusions.

In this research, no definite way of detecting and measuring errors was formulated and utilised. The tasks performed were also simplistic. More complex tasks for the users to perform on the websites may have yielded different results and led to error checking being a necessity.

There was no web accessibility testing and checking for compliance with WCAG guidelines. Though the web prototypes were very realistic and generated on web browsers, they could not be accessed by accessibility testing tools as they were not hosted on a public URL. Therefore, the research focused more on usability and user satisfaction.

7 Conclusion

In this section, research questions formulated at the beginning of the study are answered and further recommended work discussed.

7.1.1 Research Question 1

Skeuomorphic or flat interface; which provides better features for the identification and recall of a news website's components and content?

To answer this question the results of all the tasks performed in the experiments and some questions from the post-experiment questionnaire that are directly linked to identifying web items are considered. All the tasks of the experiment involved finding an item on the web prototypes. In measuring performance based on task completion time, no statistically significant result placed one interface type above the other. However, those results showed the skeuomorphic interface produced slightly quicker times in four (4) out of the six (6) tasks when the user sample is combined. Questions 1,2,3, and 5 of the post-experiment questionnaire are directly related to the recognition and recall usability heuristics, and these questions all produced statistically significant results; the combined user sample rating the flat interface higher than the skeuomorphic interface. On the one hand, performance seemed better on the skeuomorphic interface, albeit with no statistically significant result. On the other hand, the questionnaire data showed more statistically significant results of users in favour of the flat interface. It leads to a dilemma, but because the performance results were not statistically significant, the conclusion is that the flat interface seems to provide better affordance for identification and recall in the experiment. It is also possible that users were more in favour of the flat interface when rating it in the questionnaire because they decide to go for the most attractive biased opinion.

7.1.2 Research Question 2

Skeuomorphic or flat interface; which enables users to acquire information from news articles, headlines, substories and other items on a news website more efficiently and with the least time spent?

This research question is focused on performance in terms of task completion time between the two user interface types. Considering the interface types without separating the user sample into groups, the results showed no statistical significance in all tasks. Thus, the answer to this research question remains unclear.

7.1.3 Research Question 3

Skeuomorphic or flat interface; which provide better usability and user satisfaction for short-sighted visually impaired users and visually unimpaired users using a news website?

To answer this research question, the results from the pairwise comparison of user groups and interface types in the tasks and the user satisfaction ratings from the post-experiment usability questionnaire are considered. Only Task 2 produced a statistically significant result; with the visually impaired users completing the task faster with the flat interface than their counterparts. Questions 2 and 5 had statistically significant results; with the visually unimpaired users giving higher ratings to the skeuomorphic website and the visually impaired users giving higher ratings to the skeuomorphic website respectively. These three results provide no apparent pattern. The first one showed the suitability of the flat interface to the visually impaired users, the next showed the suitability of the skeuomorphic interface to the visually unimpaired users, and the last showed the suitability of the skeuomorphic interface to the visually impaired users. Research question 3 is, therefore, inconclusive from the results. Further experiments with a broader user sample and website interfaces designed with more extreme features that make differences more glaring may help elicit conclusive results.

7.1.4 Research Question 4

Skeuomorphic or flat interface; which better allows for a universally designed website?

Relevant and related data is matched with related universal design principles to determine which user interface design is more inclusive. Four (4) out of the seven (7) principles of universal design are relevant to this study.

Equitable Use: It is pertinent that the design can be used by all users in equal measure. When considering performance in terms of task completion time, both the visually unimpaired users and the visually impaired short-sighted users should be able to complete tasks on whichever interface design in almost equal time. The quantitative results of the experiment mostly showed no statistical difference in task completion times of both user groups regarding interface type. Only one result was statistically significant; in Task 2, the visually impaired users had a quicker time than the visually unimpaired users with the flat interface prototype. Questions 2 & 4 of the post-experiment questionnaire are closely related to the principle of equitable use, especially the guideline of making a design appealing to all users. In question 2, the visually unimpaired user group rated the skeuomorphic interface higher than their visually impaired counterparts.

In contrast, the flat interface was rated higher than the skeuomorphic interface by the combined user sample. This question was about the appeal and comfort of the colours and colour contrast used on the web pages. Whereas in question 4, which asked users about the appearance and feel of the news websites, there was no statistically significant result. With the higher performance of the visually impaired users using the flat interface, the higher rating of the flat interface by the combined user sample and the more positive subjective opinion of visually impaired users towards the flat interface, it is maybe said that this type of interface design better fulfils the principle of equitable use.

Simple & Intuitive Use: A design should be easy to understand and utilise, irrespective of whether a user has previous knowledge. Questions 1,3 & 6 are closely related to this principle. All three had a statistically significant result with the flat interface rated higher than the skeuomorphic interface by the combined user sample. In question 1, the visually impaired user group scored the flat interface higher than the visually unimpaired user group. Although this result was not statistically significant, it gives a pointer that the impaired users were comfortable with the flat design. Therefore from the experiment, the flat interface better suited the principle of simple & intuitive use.

Perceptible Information: One of the guidelines in this principle states that the design should adequately differentiate between important information and background or nonessential content. Question 7 in the questionnaire is related to this guideline. Users are asked how easy it was to distinguish between clickable and non-clickable parts of the website. There was no statistically significant result generated by this question. Therefore from the data, it is safe to say that both interface designs were on equal footing as relates to perceptible information.

Low physical effort: This principle relates to the efficiency of using an interface design approach. Here question 5 of the post-experiment questionnaire is taken into consideration, evaluating the ease of completing the most complicated task in the experiment. To find the reader's incident report graphic/icon, enter and submit text using the form, more effort is required in comparison to other tasks. The statistically significant result from question 5 showed that the flat interface was rated higher than the skeuomorphic interface by the combined user sample. Therefore, the flat interface may be said to suit the principle of low physical effort better.

In summary, the flat interface design of the news website prototype may be more in line with the principles of universal design. This conclusion is reached from the results of the data collected in the research experiment, with a caveat of many results not being statistically significant. Some deviations in the trend of the results, statistically insignificant results and not large enough sample size may have affected this outcome.

Every stage of this research has been adequately thought through, combining theoretical and practical knowledge of subject topics and previous works with some educated assumptions. There has not been much research done in investigating design approaches and users with impairments. The choice was made to only recruit students at the university for experiments, as there would most likely be challenges recruiting older people if age was to be considered. Communication problems due to a language barrier would have been a factor. Designing the actual website prototypes was a creative process that illuminated the difference between two UI design approaches. The skeuomorphic design provided elevated surfaces, highlighted items and real-world representations.

In contrast, the flat design showcased a minimalistic outlook, getting rid of metaphors that may be seen as visually distracting. When conducting experiments, the order in which users used a website prototype was flipped from one user to the next, with visually unimpaired users beginning with the skeuomorphic interface while the visually unimpaired users starting with the flat interface. More can be done to make the process random and reduce the effect of users knowing the exact place to click when completing a task on the second interface. Conducting the experiments was a rewarding process that was made flexible enough to cater for human effects and behaviours. This study was positively challenging and ultimately productive, doing a great deal to advance the conversation of universal design in user interface design.

7.2 Further Research

Taking this research further may involve expanding several determinants. Websites are not only utilised on large screens, investigating the same concepts in small screens of mobile devices is necessary. More work can be done in exploring the same concepts in this study with more varying user sample, for example, users with other physical and visual impairments, users with different levels of web competence—furthermore, a specialised investigation into the accessibility of skeuomorphic and flat interfaces and their compliance with WCAG.

8 Reference list

10 Heuristics for User Interface Design: Article by Jakob Nielsen. (n.d.). Retrieved November 21, 2019, from Nielsen Norman Group website: https://www.nngroup.com/articles/ten-usability-heuristics/

Apple's History of Skeuomorphism. (n.d.). Retrieved May 21, 2019, from http://eggfreckles.net/favorite/skeuomorphism/

Axure RP 9 - Prototypes, Specifications, and Diagrams in One Tool. (n.d.). Retrieved November 21, 2019, from Axure website: https://www.axure.com/

Burmistrov, I., Zlokazova, T., Izmalkova, A., & Leonova, A. (2015). Flat Design vs Traditional Design: Comparative Experimental Study. *Human-Computer Interaction – INTERACT 2015*, pp. 106–114. https://doi.org/10.1007/978-3-319-22668-2_10

Cooper, A., Reimann, R., Cronin, D., & Noessel, C. (2014). *About Face: The Essentials of Interaction Design* (4th ed.). Wiley Publishing.

Cousins, C. (2013, May 28). Principles of Flat Design - Designmodo. Retrieved November 22, 2019, from Designmodo website: https://designmodo.com/flat-design-principles/

Cypriano, L., & Pinheiro, M. (2015). Prototyping and Testing Throughout all the Design Process as a Methodology for Developing Interaction Design Projects. *Design, User Experience, and Usability: Design Discourse*, pp. 157–166. https://doi.org/10.1007/978-3-319-20886-2_16

Definition of DESIGN. (n.d.). Retrieved May 18, 2019, from https://www.merriam-webster.com/dictionary/design

Eroglu, S. A., Machleit, K. A., & Davis, L. M. (2001). Atmospheric qualities of online retailing. *Journal of Business Research*, Vol. 54, pp. 177–184. https://doi.org/10.1016/s0148-2963(99)00087-9

Flat-Design Best Practices. (n.d.). Retrieved May 21, 2019, from Nielsen Norman Group website: https://www.nngroup.com/articles/flat-design-best-practices/

Flat Design: Its Origins, Its Problems, and Why Flat 2.0 Is Better for Users. (n.d.-a). Retrieved May 13, 2019, from Nielsen Norman Group website: https://www.nngroup.com/articles/flat-design/

Flat Design: Its Origins, Its Problems, and Why Flat 2.0 Is Better for Users. (n.d.-b). Retrieved May 21, 2019, from Nielsen Norman Group website: https://www.nngroup.com/articles/flat-design/

Flat Pixels: The Battle Between Flat Design And Skeuomorphism. (n.d.). Retrieved May 15, 2019, from http://sachagreif.com/flat-pixels/

Gross, S., Bardzell, J., & Bardzell, S. (2013). Skeu the evolution. *Proceedings of the 8th International Conference on Tangible, Embedded and Embodied Interaction - TEI '14*. https://doi.org/10.1145/2540930.2540969

Idler, S. (2013). Flat web design is here to stay. *Usabilla, Amsterdam*.

ISO. (2018). Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts (ISO 9241-11:2018en). Retrieved November 16, 2019, from International Standards Organisation website: https://www.iso.org/obp/ui/#iso:std:iso:9241:-11:ed-2:v1:en

Jung, H., Wiltse, H., Wiberg, M., & Stolterman, E. (2017). Metaphors, materialities, and affordances: Hybrid morphologies in the design of interactive artifacts. *Design*

Studies, Vol. 53, pp. 24–46. https://doi.org/10.1016/j.destud.2017.06.004

Lee, S. (2005). Jenny Preece, Yvonne Rogers, and Helen Sharp (Eds.): Interaction Design: Beyond Human-Computer Interaction. *Information Design Journal*, Vol. 13, pp. 264–266. https://doi.org/10.1075/idjdd.13.3.15lee

Lewis, C., & Mack, R. (1982). Learning to use a text processing system. *Proceedings of the 1982 Conference on Human Factors in Computing Systems - CHI '82*. https://doi.org/10.1145/800049.801817

Li, C. F., Shi, H. T., Huang, J. J., & Chen, L. Y. (2014). Two Typical Symbols in Human-Machine Interactive Interface. *Applied Mechanics and Materials*, Vol. 635–637, pp. 1659–1665. https://doi.org/10.4028/www.scientific.net/amm.635-637.1659

Mayers, A. (2013). *Introduction to Statistics and SPSS in Psychology*. Pearson Higher Ed.

Mkrtchyan, R. (2018, June 26). Wireframe, Mockup, Prototype: What is What? Retrieved May 22, 2019, from UX Planet website: https://uxplanet.org/wireframe-mockup-prototype-what-is-what-8cf2966e5a8b

Moggridge, B. (2006). Designing Interactions. *MIT Press Books*, *1*. Retrieved from https://ideas.repec.org/b/mtp/titles/0262134748.html

National Disability Authority. (n.d.). Definition and overview. Retrieved May 21, 2019, from http://universaldesign.ie/What-is-Universal-Design/Definition-and-Overview/

Nielsen, J. (1995). 10 usability heuristics for user interface design. *Nielsen Norman Group*, *1*(1). Retrieved from http://courses.ischool.utexas.edu/rbias/2014/Spring/INF385P/files/10%20Usability%20Heuristics%20for%20User%20Interface%20Design.docx

Nilsson, E. G. (2009). Design Patterns for User Interface for Mobile Applications. *Computer-Aided Design of User Interfaces VI*, pp. 307–312. https://doi.org/10.1007/978-1-84882-206-1_28

Norman, D. A. (2002). *The Design of Everyday Things*. New York, NY, USA: Basic Books, Inc.

Norman, D. A. (2008). THE WAY I SEE IT Signifiers, not affordances. *Interactions*, *15*(6), 18–19.

Oswald, D., Kolb, S., & Others. (2014). Flat design vs. skeuomorphism--effects on learnability and image attributions in digital product interfaces. *DS 78: Proceedings of the 16th International Conference on Engineering and Product Design Education (E&PDE14), Design Education and Human Technology Relations, University of Twente, The Netherlands, 04-05.09. 2014*, 402–407. designsociety.org.

Pandab, P. (n.d.). Ingredients of Good Design: Affordance, Emotion and Complexity. Retrieved May 15, 2019, from https://www.researchgate.net/profile/Pratyush_Pandab2/publication/266899536_Ingredients_of_Good_Design_Affordance_Emotion_and_Complexity/links/543e794e0cf2e76f022280d7.pdf

Pelet, J.-É., & Taieb, B. (2017). From Skeuomorphism to Flat Design: When Font and Layout of M-Commerce Websites Affect Behavioral Intentions. Advances in National Brand and Private Label Marketing, pp. 95–103. https://doi.org/10.1007/978-3-319-59701-0_11

Pelet, J.-É., & Taieb, B. (n.d.). Enhancing the Mobile User Experience Through Colored Contrasts. *Encyclopedia of Information Science and Technology, Fourth Edition*, pp. 6070–6082. https://doi.org/10.4018/978-1-5225-2255-3.ch527

Prototyping Model in Software Engineering: Methodology, Process, Approach. (n.d.). Retrieved November 21, 2019, from https://www.guru99.com/software-engineering-prototyping-model.html

Rees, D. (2015, June 1). What is wireframing | Experience UX. Retrieved May 22, 2019, from Experience UX website: https://www.experienceux.co.uk/faqs/what-is-wireframing/

Rose, P. (2013). Skeuomorphism as an Affordance: A principle for interaction and user interface design. *University of Plymouth*. Retrieved from http://phil-rose.co.uk/phil-rose-dissertation.pdf

Sauro, J., & Lewis, J. R. (2012). Quantifying User Research. *Quantifying the User Experience*, pp. 9–18. https://doi.org/10.1016/b978-0-12-384968-7.00002-3

Schneidermeier, T., Hertlein, F., & Wolff, C. (2014). Changing Paradigm – Changing Experience? *Design, User Experience, and Usability. Theories, Methods, and Tools for Designing the User Experience*, pp. 371–382. https://doi.org/10.1007/978-3-319-07668-3_36

Spiliotopoulos, K., Rigou, M., & Sirmakessis, S. (2018). A Comparative Study of Skeuomorphic and Flat Design from a UX Perspective. *Multimodal Technologies and Interaction*, Vol. 2, p. 31. https://doi.org/10.3390/mti2020031

Stickel, C., Pohl, H.-M., & Milde, J.-T. (2014). Cutting Edge Design or a Beginner's Mistake? – A Semiotic Inspection of iOS7 Icon Design Changes. *Design, User Experience, and Usability. User Experience Design for Diverse Interaction Platforms and Environments*, pp. 358–369. https://doi.org/10.1007/978-3-319-07626-3_33

Urbano, I. C. V. P., Inês Cunha Vaz, Guerreiro, J. P. V., & Hugo Miguel Aleixo. (2020). From skeuomorphism to flat design: age-related differences in performance and aesthetic perceptions. In *Behaviour & Information Technology* (pp. 1–16). https://doi.org/10.1080/0144929x.2020.1814867

Westlund, O. (2013). Mobile news: A review and model of journalism in an age of mobile media. *Digital Journalism*, *1*(1), 6–26.

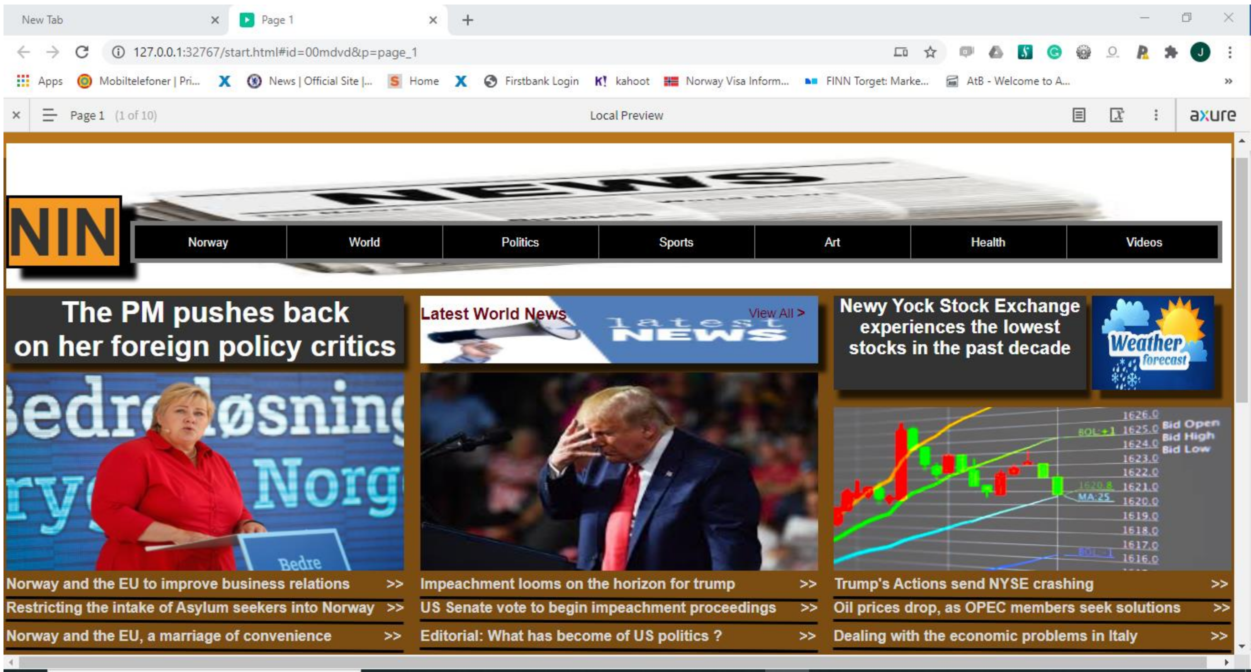
When Flat Design Falls Flat. (2013, November 4). Retrieved May 21, 2019, from WebFX Blog website: https://www.webfx.com/blog/web-design/when-flat-design-falls-flat/

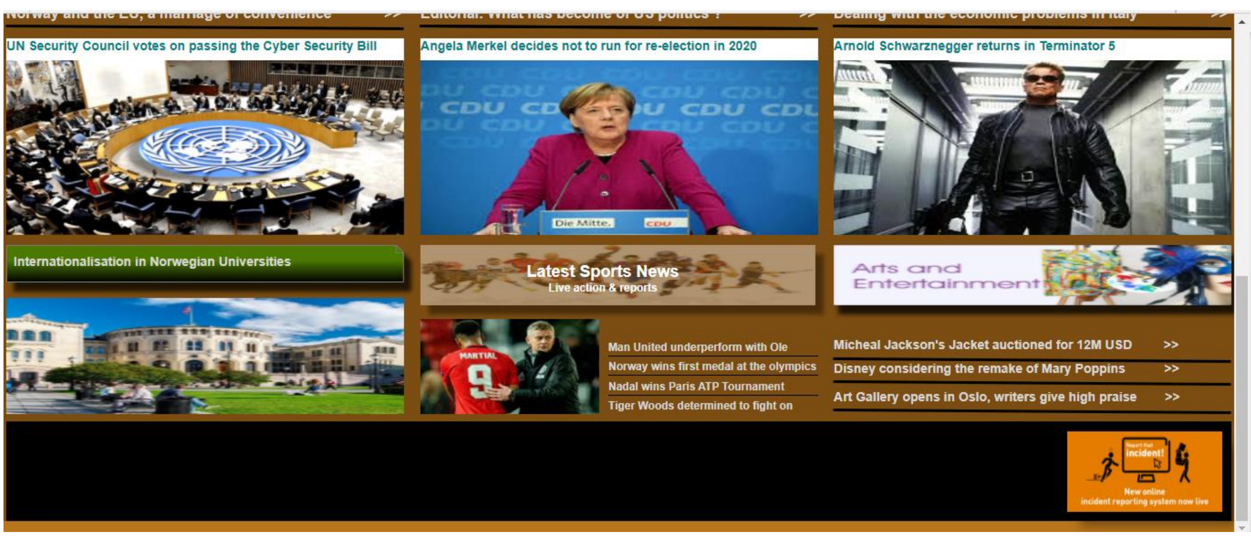
Wu, L., Lei, T., Li, J., & Li, B. (2015). Skeuomorphism and Flat Design: Evaluating Users' Emotion Experience in Car Navigation Interface Design. *Design, User Experience, and Usability: Design Discourse*, pp. 567–575. https://doi.org/10.1007/978-3-319-20886-2_53

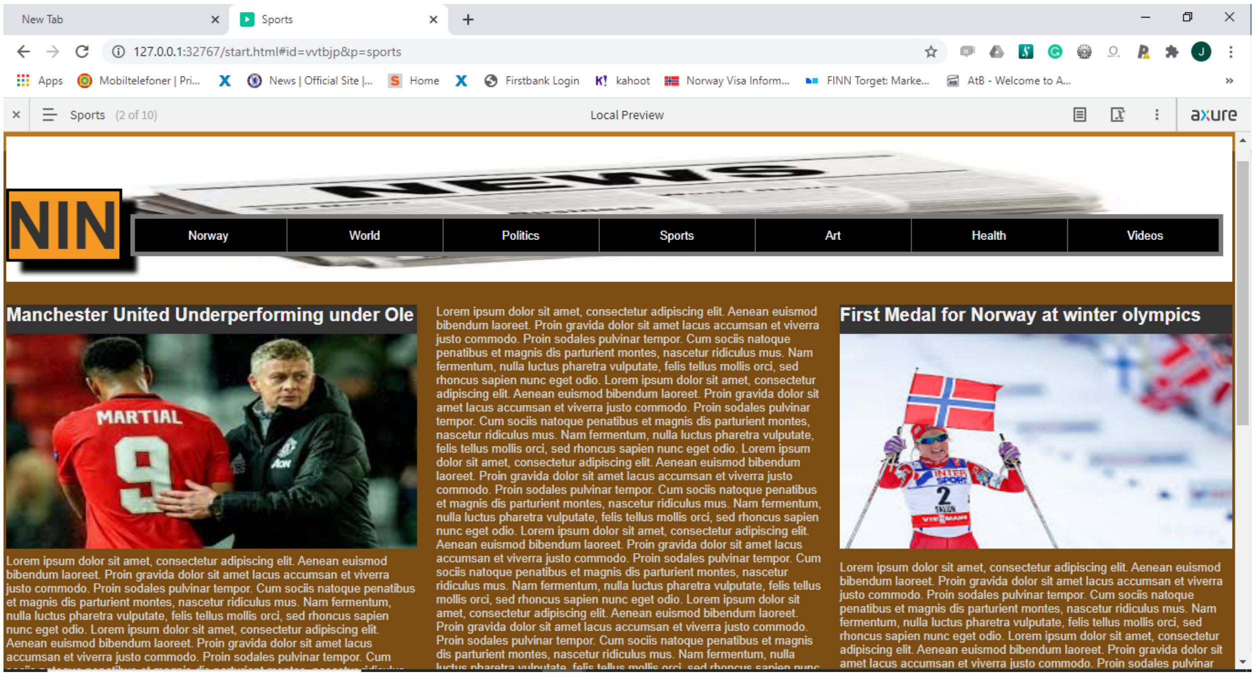
Zhang, X., Wang, Q., & Shi, Y. (2017). Contrastive Analysis on Emotional Cognition of Skeuomorphic and Flat Icon. *Lecture Notes in Electrical Engineering*, pp. 225–232. https://doi.org/10.1007/978-981-10-3530-2_28

9 Appendix A

9.1 Images of the Skeuomorphic interface






New Tab
Sports
127.0.0.1:32767/start.html#id=vvtbjp&p=sports
Sports (2 of 10)
Local Preview
axure
NIN
NEWS
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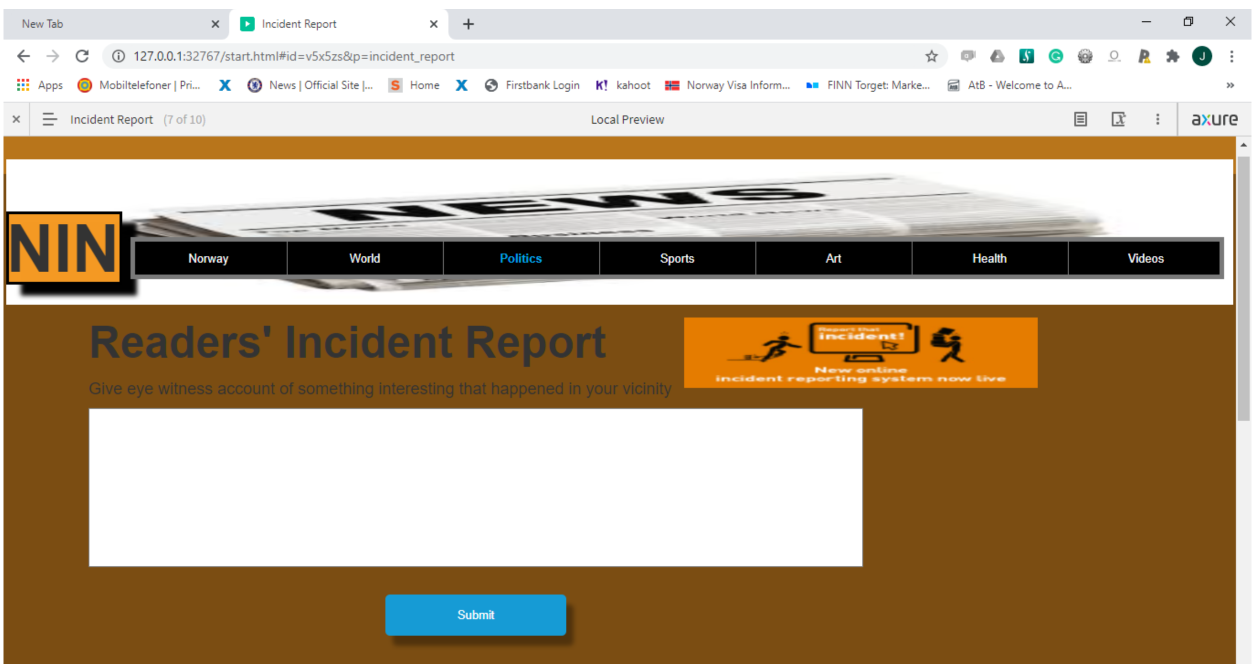
World
Politics
Sports
Art
Health
Videos
Manchester United Underperforming under Ole
MARTIAL
First Medal for Norway at winter olympics


New Tab
Incident Report
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Incident Report (7 of 10)
Local Preview
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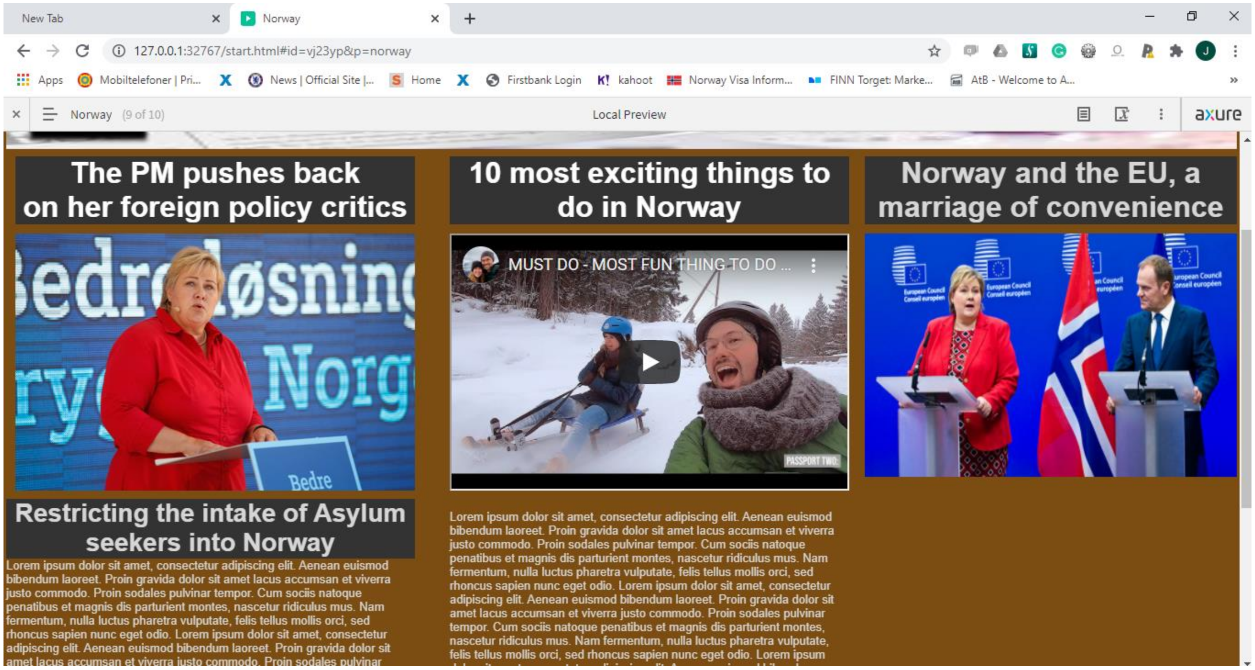
NIN
NEWS
Norway
World
Politics
Sports
Art
Health
Videos
Readers' Incident Report
Give eye witness account of something interesting that happened in your vicinity
incident!
New online
incident reporting system now live
Submit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Norway
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Norway (9 of 10)
Local Preview
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10 most exciting things to do in Norway
Norway and the EU, a marriage of convenience
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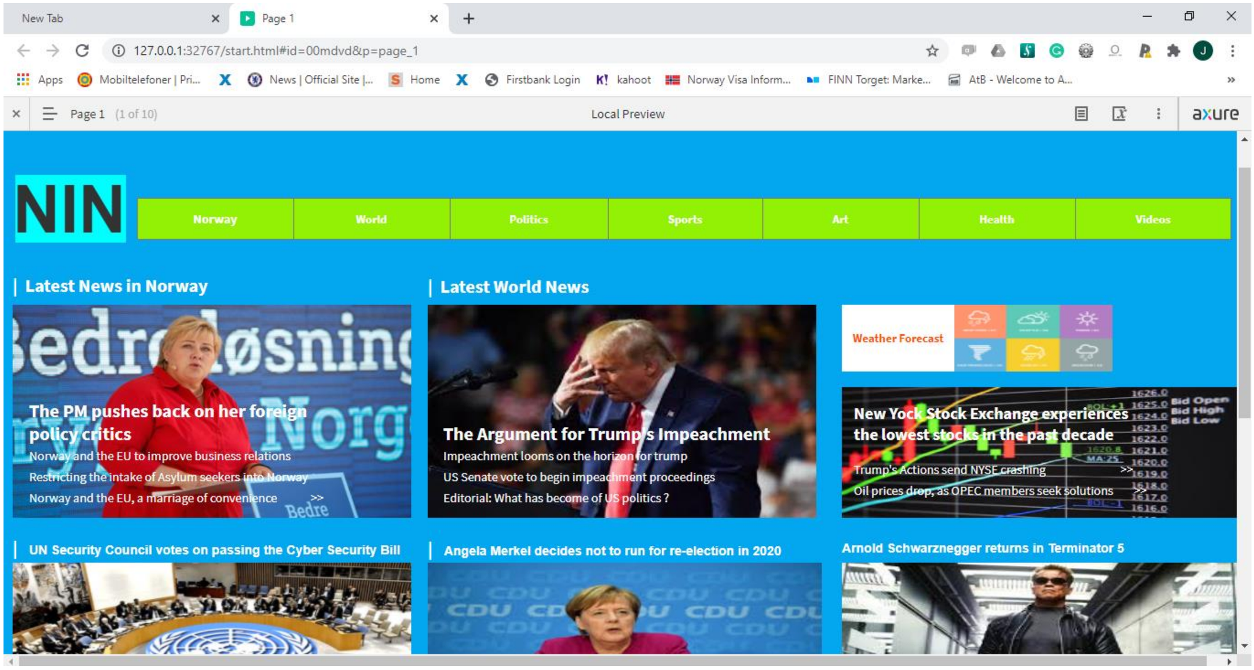
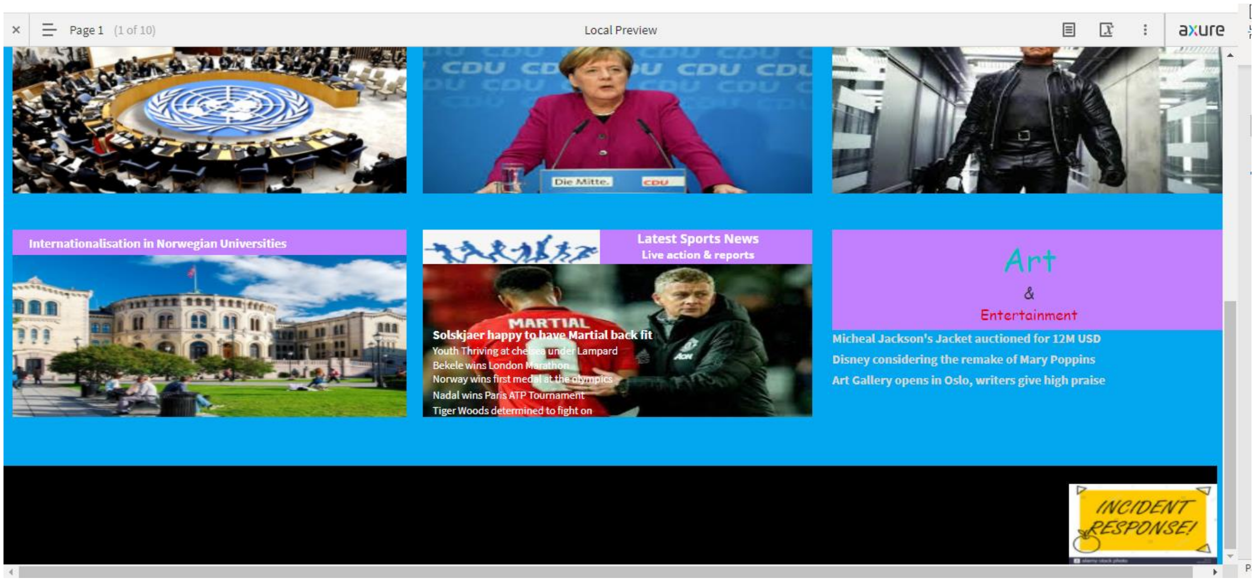
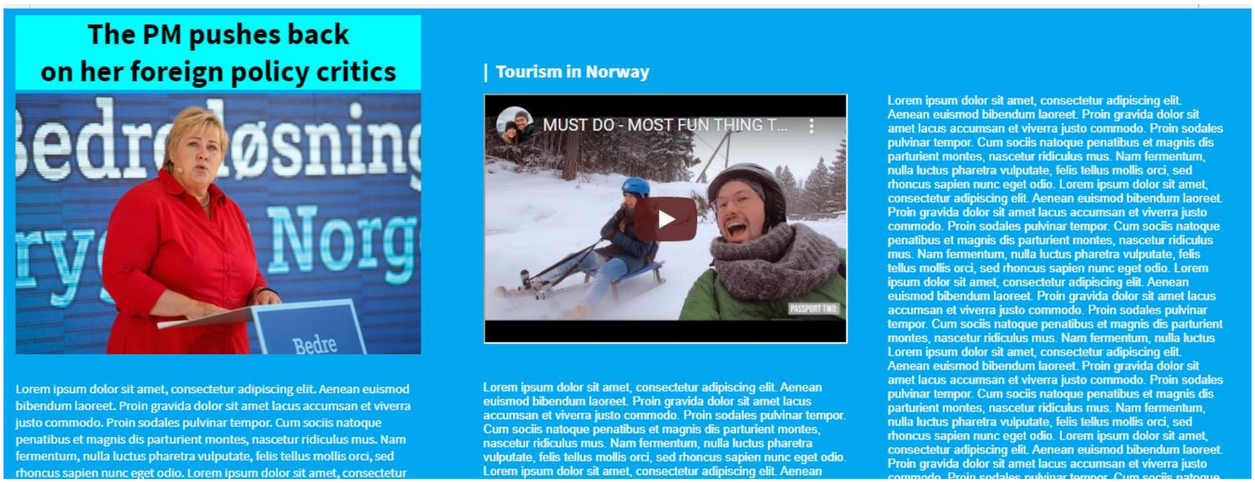
Report that
incident!
New online
incident reporting system now live

9.2 Images of the Flat Interface







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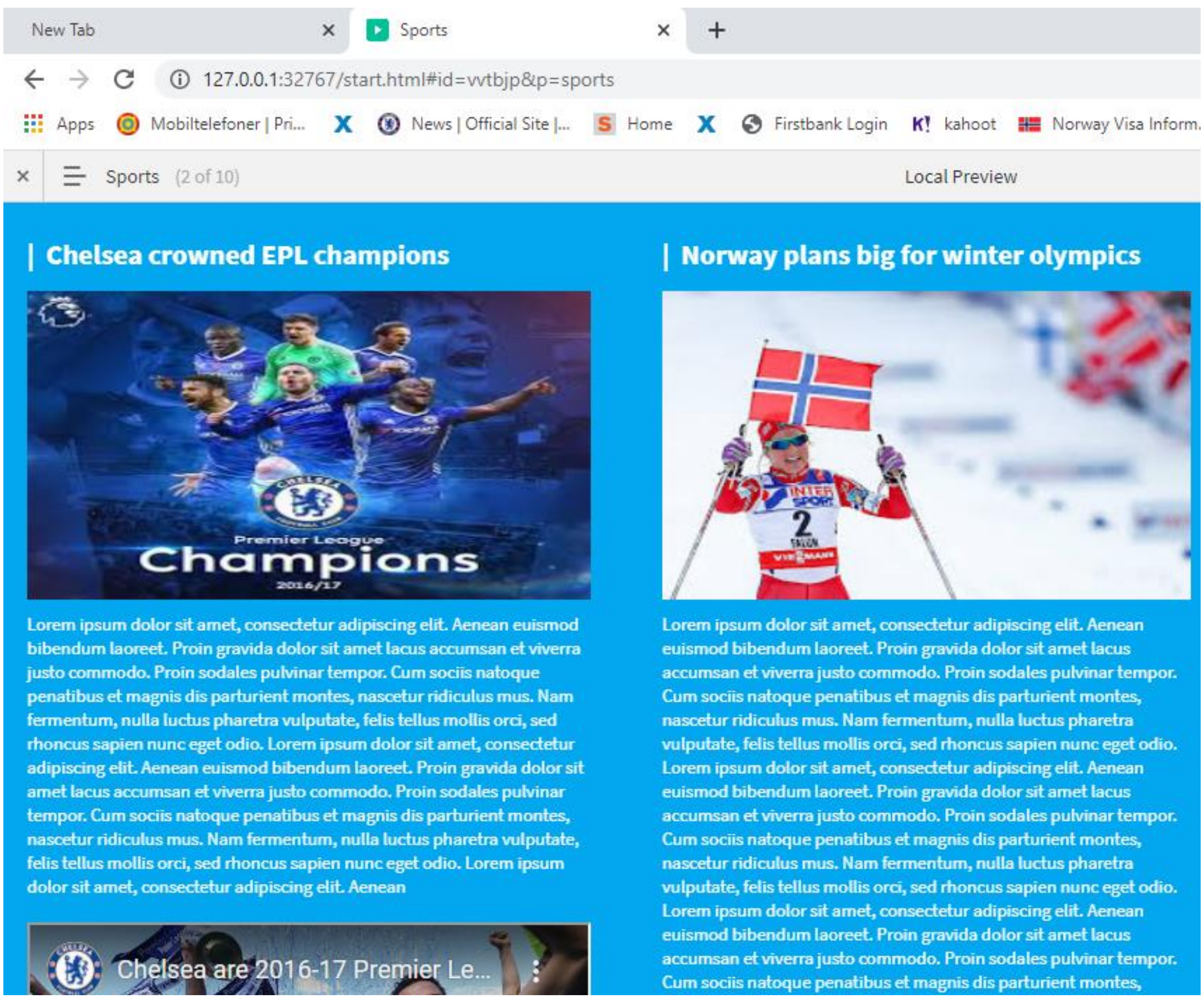

New Tab
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Sports (2 of 10)
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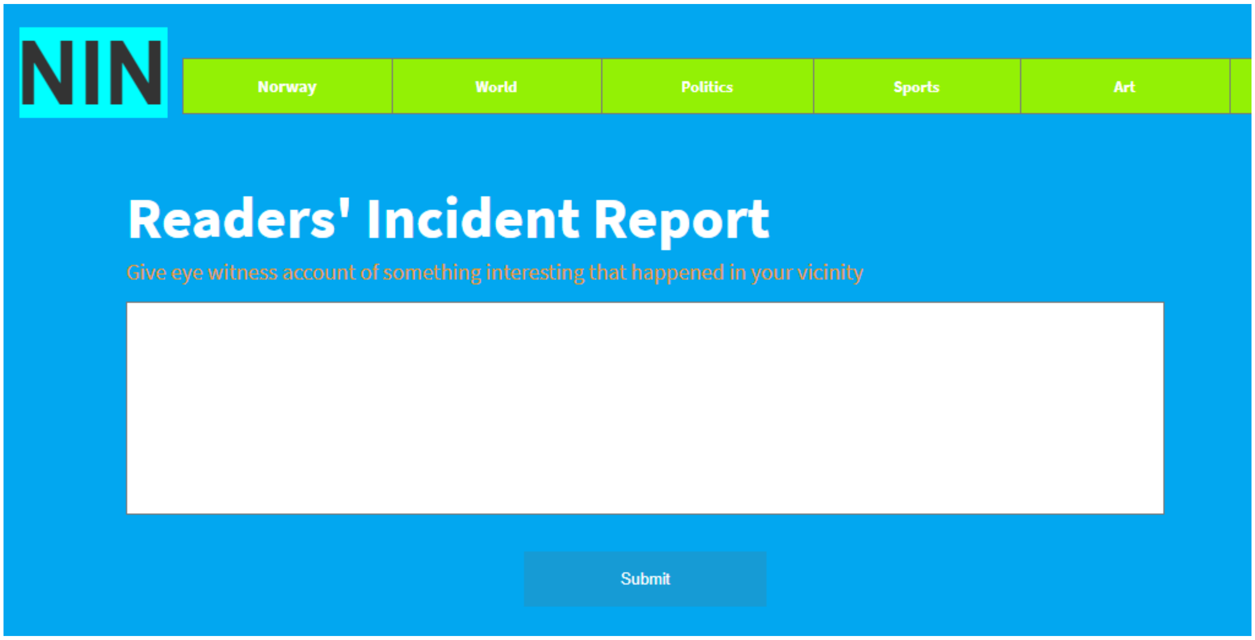
NIN
Norway
World
Politics
Sports
Art
Readers' Incident Report
Give eye witness account of something interesting that happened in your vicinity
Submit

10 Appendix B

10.1 Task data and detailed statistics

	Unimpaired	P1	P2	P3	P4	P5	P6	P7
Task 1	**Skeu**	12.36	9.8	11.4	7.7	13.05	10.7	9.55
	Flat	14.8	15.5	4.97	16.5	10.07	15.35	7.99
Task 2	**Skeu**	11.34	6.67	6.68	8.22	5.5	6.05	2.23
	Flat	5.9	17.01	11.06	15.87	15.9	6.98	4.45
Task 3	**Skeu**	17.2	10.33	11.99	8.9	16.5	6.93	12.2
	Flat	9.88	14.55	8.86	12.33	5.1	7.76	10.2
Task 4	**Skeu**	6.3	3.38	5.1	2.87	4.3	3.22	3.9
	Flat	3.93	5.4	4.77	4.44	3.33	4.2	2.59
Task 5	**Skeu**	30.98	20.3	25.77	5.56	31.86	9.2	11.2
	Flat	36.44	35.78	24.49	35.73	14.47	37.7	8.98
Task 6	**Skeu**	12.46	6.1	5.3	5.59	10.7	6.97	5.97
	Flat	7.29	8.5	6.61	6.09	6.57	7.2	5.8

8.7	5.6	7.5	**Flat**	6.95	4.83	5.96	7.44	9.48	5.3	7.47
9.99	9.65	5.01	**Skeu**	9.89	5.38	4.78	7.56	9.44	4.55	10.23
19.2	12.77	9.74	**Flat**	28.81	16.04	14.74	13.2	15.57	30.33	12.43
10.4	15.2	6.29	**Skeu**	25.73	17.34	11.62	12.76	30.2	31.56	13.33
6.22	3.07	3.29	**Flat**	3.47	5.07	2.22	3.64	4.3	3.11	4.12
4.1	4.02	2.73	**Skeu**	4.26	5.7	2.22	4.15	5.32	3.35	3.54
7.91	7.04	10.9	**Flat**	9.52	10.09	7.96	8.6	10.02	12.9	4.33
6.94	11.36	7.51	**Skeu**	6.55	9.52	7.8	8.65	12.2	9.22	8.2
7.5	3.02	9.23	**Flat**	2.15	5.3	2.82	5.74	2.55	9.2	3.53
8.8	2.27	6.17	**Skeu**	3.79	4.22	2.36	8.56	3.92	9.2	6.5
12.4	8.88	11.5	**Flat**	14.74	9.1	9.47	10.44	8.54	7.91	9.23
10.1	10.01	8.7	**Skeu**	9.69	13.47	10.2	8.9	12.43	12.37	11.34
P8	P9	P10	Impaired	P1	P2	P3	P4	P5	P6	P7

P8	10.2	9.43	10.2	10.87	9.54	8.07	3.44	4.5	25.33	24.01	10.39	9.4
P9	10.3	10.55	8.43	4.7	6.7	5.9	3.84	3.07	20.2	12.04	16.3	9.3
P10	9.97	7.1	4.21	2.44	8.48	7.65	2.34	3.01	16.1	9.05	8.2	6.4

Table 10-1. Task completion time data collected from experiments. Times are in seconds.

Descriptives

Visual Capacity				Statistic	Std. Error
Skeu	Unimpaired	Mean		10.3370	.51011
		95% Confidence Interval for Mean	Lower Bound	9.1831	
			Upper Bound	11.4909	
		5% Trimmed Mean		10.3328	
		Median		10.0550	
		Variance		2.602	
		Std. Deviation		1.61311	
		Minimum		7.70	
		Maximum		13.05	
		Range		5.35	
		Interquartile Range		2.30	
		Skewness		.201	.687
		Kurtosis		-.206	1.334
	Impaired	Mean		10.8870	.45908
		95% Confidence Interval for Mean	Lower Bound	9.8485	
			Upper Bound	11.9255	
		5% Trimmed Mean		10.8539	
		Median		10.2500	
		Variance		2.108	
		Std. Deviation		1.45173	
		Minimum		8.90	
		Maximum		13.47	
		Range		4.57	
		Interquartile Range		2.48	
		Skewness		.594	.687
		Kurtosis		-.704	1.334
Flat	Unimpaired	Mean		11.7960	1.20424
		95% Confidence Interval for Mean	Lower Bound	9.0718	
			Upper Bound	14.5202	
		5% Trimmed Mean		11.9139	
		Median		11.9500	
		Variance		14.502	
		Std. Deviation		3.80813	
		Minimum		4.97	
		Maximum		16.50	
		Range		11.53	
		Interquartile Range		6.73	
		Skewness		-.443	.687
		Kurtosis		-.830	1.334
	Impaired	Mean		9.6510	.65544
		95% Confidence Interval for Mean	Lower Bound	8.1683	
			Upper Bound	11.1337	
		5% Trimmed Mean		9.5100	
		Median		9.3300	
		Variance		4.296	
		Std. Deviation		2.07268	
		Minimum		7.10	
		Maximum		14.74	
		Range		7.64	
		Interquartile Range		2.08	
		Skewness		1.708	.687
		Kurtosis		4.234	1.334

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Interface	Sphericity Assumed	0.124	1	0.124	0.017	0.898	0.001
	Greenhouse-Geisser	0.124	1.000	0.124	0.017	0.898	0.001
	Huynh-Feldt	0.124	1.000	0.124	0.017	0.898	0.001
	Lower-bound	0.124	1.000	0.124	0.017	0.898	0.001
Interface * Visual	Sphericity Assumed	18.158	1	18.158	2.477	0.133	0.121
	Greenhouse-Geisser	18.158	1.000	18.158	2.477	0.133	0.121
	Huynh-Feldt	18.158	1.000	18.158	2.477	0.133	0.121
	Lower-bound	18.158	1.000	18.158	2.477	0.133	0.121
Error(Interface)	Sphericity Assumed	131.940	18	7.330			
	Greenhouse-Geisser	131.940	18.000	7.330			
	Huynh-Feldt	131.940	18.000	7.330			
	Lower-bound	131.940	18.000	7.330			

Task 2

Descriptives

	Visual Capacity			Statistic	Std. Error
Skeu	Unimpaired	Mean		6.3930	.87596
		95% Confidence Interval for Mean	Lower Bound	4.4114	
			Upper Bound	8.3746	
		5% Trimmed Mean		6.3494	
		Median		6.4200	
		Variance		7.673	
		Std. Deviation		2.77004	
		Minimum		2.23	
		Maximum		11.34	
		Range		9.11	
		Interquartile Range		3.67	
		Skewness		-.012	.687
		Kurtosis		.234	1.334
	Impaired	Mean		6.1390	.87704
		95% Confidence Interval for Mean	Lower Bound	4.1550	
			Upper Bound	8.1230	
		5% Trimmed Mean		6.1233	
		Median		5.3600	
		Variance		7.692	
		Std. Deviation		2.77344	
		Minimum		2.36	
		Maximum		10.20	
		Range		7.84	
		Interquartile Range		4.83	
		Skewness		.194	.687
		Kurtosis		-1.729	1.334
Flat	Unimpaired	Mean		9.6920	1.60166
		95% Confidence Interval for Mean	Lower Bound	6.0688	
			Upper Bound	13.3152	
		5% Trimmed Mean		9.6561	
		Median		8.3650	
		Variance		25.653	
		Std. Deviation		5.06489	
		Minimum		3.02	
		Maximum		17.01	
		Range		13.99	
		Interquartile Range		10.34	
		Skewness		.367	.687
		Kurtosis		-1.409	1.334
	Impaired	Mean		4.9300	.94497
		95% Confidence Interval for Mean	Lower Bound	2.7923	
			Upper Bound	7.0677	
		5% Trimmed Mean		4.7544	
		Median		4.1150	
		Variance		8.930	
		Std. Deviation		2.98826	
		Minimum		2.15	
		Maximum		10.87	
		Range		8.72	
		Interquartile Range		4.08	
		Skewness		1.174	.687
		Kurtosis		.401	1.334

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Interface	Sphericity Assumed	10.920	1	10.920	1.532	.232	.078
	Greenhouse-Geisser	10.920	1.000	10.920	1.532	.232	.078
	Huynh-Feldt	10.920	1.000	10.920	1.532	.232	.078
	Lower-bound	10.920	1.000	10.920	1.532	.232	.078
Interface * Visual	Sphericity Assumed	50.805	1	50.805	7.129	.016	.284
	Greenhouse-Geisser	50.805	1.000	50.805	7.129	.016	.284
	Huynh-Feldt	50.805	1.000	50.805	7.129	.016	.284
	Lower-bound	50.805	1.000	50.805	7.129	.016	.284
Error(Interface)	Sphericity Assumed	128.274	18	7.126			
	Greenhouse-Geisser	128.274	18.000	7.126			
	Huynh-Feldt	128.274	18.000	7.126			
	Lower-bound	128.274	18.000	7.126			

Visual Capacity * Interface

Measure: MEASURE_1

Visual Capacity	Interface	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Unimpaired	1	6.393	.877	4.552	8.234
	2	9.692	1.315	6.929	12.455
Impaired	1	6.139	.877	4.298	7.980
	2	4.930	1.315	2.167	7.693

Task 3

Descriptives

	Visual Capacity			Statistic	Std. Error
Skeu	Unimpaired	Mean		10.9860	1.16106
		95% Confidence Interval for Mean	Lower Bound	8.3595	
			Upper Bound	13.6125	
		5% Trimmed Mean		10.8661	
		Median		10.8450	
		Variance		13.481	
		Std. Deviation		3.67159	

		Minimum		6.93	
		Maximum		17.20	
		Range		10.27	
		Interquartile Range		5.91	
		Skewness		.635	.687
		Kurtosis		-.589	1.334
	Impaired	Mean		8.6860	.51240
		95% Confidence Interval for Mean	Lower Bound	7.5269	
			Upper Bound	9.8451	
		5% Trimmed Mean		8.6094	
		Median		8.5650	
		Variance		2.626	
		Std. Deviation		1.62035	
		Minimum		6.55	
		Maximum		12.20	
		Range		5.65	
		Interquartile Range		2.00	
		Skewness		.860	.687
		Kurtosis		1.696	1.334
Flat	Unimpaired	Mean		9.4530	.86577
		95% Confidence Interval for Mean	Lower Bound	7.4945	
			Upper Bound	11.4115	
		5% Trimmed Mean		9.4117	
		Median		9.3700	
		Variance		7.496	
		Std. Deviation		2.73781	
		Minimum		5.10	
		Maximum		14.55	
		Range		9.45	
		Interquartile Range		3.68	
		Skewness		.369	.687
		Kurtosis		.148	1.334
	Impaired	Mean		8.5040	.74979
		95% Confidence Interval for Mean	Lower Bound	6.8079	
			Upper Bound	10.2001	
		5% Trimmed Mean		8.4917	
		Median		8.3350	
		Variance		5.622	

	Std. Deviation	2.37104	
	Minimum	4.33	
	Maximum	12.90	
	Range	8.57	
	Interquartile Range	2.82	
	Skewness	.023	.687
	Kurtosis	.745	1.334

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Interface	Sphericity Assumed	7.353	1	7.353	.943	.344	.050
	Greenhouse-Geisser	7.353	1.000	7.353	.943	.344	.050
	Huynh-Feldt	7.353	1.000	7.353	.943	.344	.050
	Lower-bound	7.353	1.000	7.353	.943	.344	.050
Interface * Visual	Sphericity Assumed	4.563	1	4.563	.585	.454	.031
	Greenhouse-Geisser	4.563	1.000	4.563	.585	.454	.031
	Huynh-Feldt	4.563	1.000	4.563	.585	.454	.031
	Lower-bound	4.563	1.000	4.563	.585	.454	.031
Error(Interface)	Sphericity Assumed	140.400	18	7.800			
	Greenhouse-Geisser	140.400	18.000	7.800			
	Huynh-Feldt	140.400	18.000	7.800			
	Lower-bound	140.400	18.000	7.800			

Task 4

Descriptives

	Visual Capacity			Statistic	Std. Error
Skeu	Unimpaired	Mean		3.9920	.34144
		95% Confidence Interval for Mean	Lower Bound	3.2196	
			Upper Bound	4.7644	
		5% Trimmed Mean		3.9339	
		Median		3.9600	
		Variance		1.166	
		Std. Deviation		1.07973	
		Minimum		2.73	
		Maximum		6.30	
		Range		3.57	
		Interquartile Range		1.37	
		Skewness		1.056	.687
		Kurtosis		1.202	1.334
	Impaired	Mean		3.8160	.35404
		95% Confidence Interval for Mean	Lower Bound	3.0151	
			Upper Bound	4.6169	
		5% Trimmed Mean		3.8000	
		Median		3.6900	
		Variance		1.253	
		Std. Deviation		1.11959	
		Minimum		2.22	
		Maximum		5.70	
		Range		3.48	
		Interquartile Range		1.43	
		Skewness		.273	.687
		Kurtosis		-.301	1.334
Flat	Unimpaired	Mean		4.1240	.35547
		95% Confidence Interval for Mean	Lower Bound	3.3199	
			Upper Bound	4.9281	
		5% Trimmed Mean		4.0928	
		Median		4.0650	
		Variance		1.264	
		Std. Deviation		1.12408	
		Minimum		2.59	
		Maximum		6.22	
		Range		3.63	
		Interquartile Range		1.69	
		Skewness		.559	.687
		Kurtosis		-.267	1.334
	Impaired	Mean		3.6510	.26869
		95% Confidence Interval for Mean	Lower Bound	3.0432	
			Upper Bound	4.2588	
		5% Trimmed Mean		3.6517	
		Median		3.5550	
		Variance		.722	
		Std. Deviation		.84966	
		Minimum		2.22	
		Maximum		5.07	
		Range		2.85	
		Interquartile Range		1.30	
		Skewness		.066	.687
		Kurtosis		-.418	1.334

Tests of Normality

	Visual Capacity	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Skeu	Unimpaired	.188	10	.200*	.920	10	.355
	Impaired	.146	10	.200*	.948	10	.651
Flat	Unimpaired	.160	10	.200*	.965	10	.846
	Impaired	.138	10	.200*	.977	10	.948

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Interface	Sphericity Assumed	.003	1	.003	.004	.952	.000
	Greenhouse-Geisser	.003	1.000	.003	.004	.952	.000
	Huynh-Feldt	.003	1.000	.003	.004	.952	.000
	Lower-bound	.003	1.000	.003	.004	.952	.000
Interface * Visual	Sphericity Assumed	.221	1	.221	.305	.588	.017
	Greenhouse-Geisser	.221	1.000	.221	.305	.588	.017
	Huynh-Feldt	.221	1.000	.221	.305	.588	.017
	Lower-bound	.221	1.000	.221	.305	.588	.017
Error(Interface)	Sphericity Assumed	13.017	18	.723			
	Greenhouse-Geisser	13.017	18.000	.723			
	Huynh-Feldt	13.017	18.000	.723			
	Lower-bound	13.017	18.000	.723			

Task 5

Descriptives

	Visual Capacity			Statistic	Std. Error
Skeu	Unimpaired	Mean		16.6760	3.14443
		95% Confidence Interval for Mean	Lower Bound	9.5628	
			Upper Bound	23.7892	
		5% Trimmed Mean		16.4500	
		Median		13.2000	
		Variance		98.875	
		Std. Deviation		9.94357	
		Minimum		5.56	
		Maximum		31.86	
		Range		26.30	
		Interquartile Range		18.60	
		Skewness		.551	.687
		Kurtosis		-1.336	1.334
	Impaired	Mean		20.4170	2.32530
		95% Confidence Interval for Mean	Lower Bound	15.1568	
			Upper Bound	25.6772	
		5% Trimmed Mean		20.2867	
		Median		18.7700	
		Variance		54.070	
		Std. Deviation		7.35325	
		Minimum		11.62	
		Maximum		31.56	
		Range		19.94	
		Interquartile Range		13.66	
		Skewness		.347	.687
		Kurtosis		-1.477	1.334
Flat	Unimpaired	Mean		23.5300	3.77971
		95% Confidence Interval for Mean	Lower Bound	14.9797	
			Upper Bound	32.0803	
		5% Trimmed Mean		23.5511	
		Median		21.8450	
		Variance		142.862	
		Std. Deviation		11.95249	
		Minimum		8.98	
		Maximum		37.70	
		Range		28.72	
		Interquartile Range		23.93	
		Skewness		.071	.687
		Kurtosis		-2.048	1.334
	Impaired	Mean		17.6220	2.34198
		95% Confidence Interval for Mean	Lower Bound	12.3241	
			Upper Bound	22.9199	
		5% Trimmed Mean		17.3922	
		Median		15.1550	
		Variance		54.849	
		Std. Deviation		7.40600	
		Minimum		9.05	
		Maximum		30.33	
		Range		21.28	
		Interquartile Range		12.88	
		Skewness		.905	.687
		Kurtosis		-.640	1.334

Tests of Normality

	Visual Capacity	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Skeu	Unimpaired	.209	10	.200*	.890	10	.169
	Impaired	.162	10	.200*	.913	10	.305
Flat	Unimpaired	.246	10	.087	.848	10	.055
	Impaired	.285	10	.021	.859	10	.074

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Interface	Sphericity Assumed	41.189	1	41.189	.673	.423	.036
	Greenhouse-Geisser	41.189	1.000	41.189	.673	.423	.036
	Huynh-Feldt	41.189	1.000	41.189	.673	.423	.036
	Lower-bound	41.189	1.000	41.189	.673	.423	.036
Interface * Visual	Sphericity Assumed	232.758	1	232.758	3.802	.067	.174
	Greenhouse-Geisser	232.758	1.000	232.758	3.802	.067	.174
	Huynh-Feldt	232.758	1.000	232.758	3.802	.067	.174
	Lower-bound	232.758	1.000	232.758	3.802	.067	.174
Error(Interface)	Sphericity Assumed	1101.874	18	61.215			
	Greenhouse-Geisser	1101.874	18.000	61.215			
	Huynh-Feldt	1101.874	18.000	61.215			
	Lower-bound	1101.874	18.000	61.215			

Task 6

Descriptives

	Visual Capacity			Statistic	Std. Error
Skeu	Unimpaired	Mean		7.7740	.84448
		95% Confidence Interval for Mean	Lower Bound	5.8636	
			Upper Bound	9.6844	
		5% Trimmed Mean		7.6672	
		Median		6.5350	
		Variance		7.131	
		Std. Deviation		2.67049	
		Minimum		5.01	
		Maximum		12.46	
		Range		7.45	
		Interquartile Range		4.65	
		Skewness		.639	.687
		Kurtosis		-1.209	1.334
	Impaired	Mean		8.6720	1.10591
		95% Confidence Interval for Mean	Lower Bound	6.1703	
			Upper Bound	11.1737	
		5% Trimmed Mean		8.4772	
		Median		8.8200	
		Variance		12.230	
		Std. Deviation		3.49720	
		Minimum		4.55	
		Maximum		16.30	
		Range		11.75	
		Interquartile Range		5.04	
		Skewness		.938	.687
		Kurtosis		1.555	1.334
Flat	Unimpaired	Mean		6.9860	.33462
		95% Confidence Interval for Mean	Lower Bound	6.2290	
			Upper Bound	7.7430	
		5% Trimmed Mean		6.9678	
		Median		6.9050	
		Variance		1.120	
		Std. Deviation		1.05816	
		Minimum		5.60	
		Maximum		8.70	
		Range		3.10	
		Interquartile Range		1.73	
		Skewness		.411	.687
		Kurtosis		-.800	1.334
	Impaired	Mean		7.2530	.53767
		95% Confidence Interval for Mean	Lower Bound	6.0367	
			Upper Bound	8.4693	
		5% Trimmed Mean		7.2639	
		Median		7.1950	
		Variance		2.891	
		Std. Deviation		1.70026	
		Minimum		4.83	
		Maximum		9.48	
		Range		4.65	
		Interquartile Range		3.53	
		Skewness		.143	.687
		Kurtosis		-1.316	1.334

Tests of Normality

	Visual Capacity	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Skeu	Unimpaired	.235	10	.126	.872	10	.105
	Impaired	.212	10	.200*	.902	10	.228
Flat	Unimpaired	.139	10	.200*	.942	10	.575
	Impaired	.186	10	.200*	.917	10	.330

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Interface	Sphericity Assumed	12.177	1	12.177	3.615	.073	.167
	Greenhouse-Geisser	12.177	1.000	12.177	3.615	.073	.167
	Huynh-Feldt	12.177	1.000	12.177	3.615	.073	.167
	Lower-bound	12.177	1.000	12.177	3.615	.073	.167
Interface * Visual	Sphericity Assumed	.995	1	.995	.295	.593	.016
	Greenhouse-Geisser	.995	1.000	.995	.295	.593	.016
	Huynh-Feldt	.995	1.000	.995	.295	.593	.016
	Lower-bound	.995	1.000	.995	.295	.593	.016
Error(Interface)	Sphericity Assumed	60.635	18	3.369			
	Greenhouse-Geisser	60.635	18.000	3.369			
	Huynh-Feldt	60.635	18.000	3.369			
	Lower-bound	60.635	18.000	3.369			

10.2 Questionnaire data

	Question 1		**Question 2**		**Question 3**		**Question 4**		**Question 5**		**Question 6**		**Question 7**		**Question 8**	
Unimpaired	**Skeu**	**Flat**	**Skeu**	**Flat**	**Skeu**	**Flat**	**Skeu**	**Flat**	**Skeu**	**Flat**	**Skeu**	**Flat**	**Skeu**	**Flat**	**Skeu**	**Flat**
P1	5	6	6	7	6	7	5	7	5	6	7	7	5	6	6	7
P2	6	7	5	6	5	6	4	6	6	7	5	5	6	7	5	6
P3	5	6	6	5	6	6	6	4	4	6	6	6	6	6	6	7
P4	5	6	7	6	5	5	6	4	5	7	7	7	5	6	4	5
P5	6	6	5	5	6	7	5	7	4	5	6	6	6	6	5	5
P6	5	7	6	5	5	5	7	5	5	6	6	5	4	4	7	7
P7	6	5	5	6	7	7	3	5	4	5	5	6	4	5	6	7
P8	7	6	7	6	6	6	6	4	5	7	6	6	7	6	5	6

6	5	Question 8	**Flat**	7	6	7	7	6	6	5
6	6		**Skeu**	7	6	7	7	6	7	6
6	4	Question 7	**Flat**	5	6	5	5	5	6	5
5	5		**Skeu**	6	7	6	5	7	5	4
4	5	Question 6	**Flat**	6	6	7	7	6	6	6
4	5		**Skeu**	6	5	6	7	7	6	5
4	5	Question 5	**Flat**	7	7	7	5	6	6	7
4	6		**Skeu**	7	6	7	5	5	6	6
5	6	Question 4	**Flat**	4	7	6	5	5	7	5
5	5		**Skeu**	6	5	4	7	4	6	6
5	4	Question 3	**Flat**	6	7	6	6	6	5	7
4	4		**Skeu**	5	6	5	4	6	5	6
5	6	Question 2	**Flat**	5	5	7	7	7	5	7
3	7		**Skeu**	4	3	3	5	4	3	5
7	7	Question 1	**Flat**	6	7	6	5	5	7	6
5	6		**Skeu**	5	6	5	4	5	6	7
P9	P10		Impaired	P1	P2	P3	P4	P5	P6	P7

P8	P9	P10
5	6	5
7	6	6
3	5	6
6	6	7
5	5	7
4	7	6
5	5	5
4	5	6
7	5	4
7	5	4
6	7	6
6	7	7
6	5	5
6	4	5
7	7	5
7	6	6

11 Appendix c

11.1 Information Sheet

Purpose of the Research

I, John Nwachukwu Okoye a master's student of Universal Design of ICT at Oslo Metropolitan University, is undertaking this research study for my thesis as part of the requirements to complete my master's program. This study compares two website interface designs and tries to determine which interface design approach provides better usability and accessibility to any user, without the need for any modification or aid. Two website prototypes have been designed, one for each kind of interface, to be used in an experiment in which you will be one of the participants to interact with the prototypes. The aim is to test these website prototypes by directly interacting with their interfaces while measurements and observation are being performed. I hope to provide a more educated response to the ongoing discussion about the interface design approach that offers more usability benefits to certain user groups.

Implication of Participation

Data will be collected during this experiment through observation, screen recording, questionnaires, and informal prompted questions. These data will be analysed in a structured manner to reach some conclusion that is both valid and complete for the scope of this study. By participating in this research study, you are being involved in critical research that I hope will go some way to making web and system interface designers take usability more into consideration when churning out web and systems interfaces. You also get to learn about the subject topic and get results and conclusion of the study when it is completed.

Procedures for Participants

You are asked to read this information sheet and sign the ethical consent form to be part of this experimental study. After that, you will perform some tasks on two News Websites that are meant to be similar, but they possess different appearances. Same tasks are to be performed on both website prototypes. The tasks to be performed are:

1. Task 1: Find the link to the news article about internationalisation in Norwegian universities.
2. Task 2: Check the weather and temperature in Oslo.
3. Task 3: Visit the sports section of the website via the sports headline in the body of the home page.
4. Task 3: Visit the sports section of the website via the sports menu.
5. Task 4: After finding and opening the Reader's Incident report, enter some text and send it.
6. Task 5: Go to the entertainment and arts section of the news.

After completing or at least attempting all tasks on both website prototypes, you will be given a questionnaire to complete. The questionnaire relates to what you could deduce and perceive, from your interactions with both websites.

Ethical Consent

All data collected will be treated confidentially. This includes data and measurements collected during the experiments, answers to questionnaires and questions. Only I and my supervisor will have access to them during this study; however, they can be viewed by the general public after submission of the thesis and storage on the internet by the university. It is important to note that no personal information will be collected from you or recorded, allowing you to remain completely anonymous. There will be no audio or video recordings of you, no names, email addresses etc. and other personally identifiable information collected.

It is voluntary to be part of this study, and you can choose to withdraw from the process at any time without providing any reason. If you have any questions concerning this study, you can please contact my thesis supervisor Pietro Murano, +47xxxxxxxx

I have received adequate information about this study, and I am willing to participate

____-

(Signed by participant, date)