

Master Thesis
in
Universal Design of ICT

May 2019

**Design, Development, and Evaluation of
Mobile Interfaces with Universally Designed
Contextual Cues**

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Preface

This master thesis will report a research conducted on mobile interface design, regarding a feature called Contextual Cues.

The goal of the project is to evaluate the portion of satisfaction and dissatisfaction regarding the contextual cue's feature on mobile interface with the notion of universal design.

There are several people and participants made this project and research possible as they participated in user testing and gave constructive feedback from two prototypes made for the project.

I would like to thank my supervisor Dr. Pietro Murano for his invaluable support and his constructive advice during this journey. His guide has been shaped the research project and put the project into the right way.

This education has given me an invaluable understanding of how to formulate problem statements. Moreover, how to formulate solution statements based on the problems approach. In other words, how through critical thinking and design thinking solve complex problems.

This education has given me a knowledge of conducting research by reading diverse range of academic papers, peer reviews as well as conference letters from ACM digital library and IEEE Xplore, google scholar and books in the area of universal design. The approach is to understand accessibility of user interface design in both platforms' such as web and mobile.

Understanding of how technical interview should be conducted for user testing and product evaluation.

Lastly, I would like to thank the university, the department of computer science and the faculty of technology art and design for the educational facilities as well as the education opportunity given to me.

Nima Eivazzadeh Kaljahi

Oslo, May 16, 2019

Abstract

The universal design of information and communication technology (UD-ICT) is a principle that ensures usability and accessibility in ICT products, and it gives the equal ability to participate in society for all people.

The goal of the master thesis is to design, develop and evaluate a mobile interface with universally designed contextual cues. In other words, the purpose of the research question is to define that whether contextual cues feature on mobile interface has a positive effect on accessibility on a mobile platform and makes the interaction more simple, understandable and robust or not.

To obtain thesis goal, research conducted from diverse scientific resources such as ACM Digital Library, IEEE Xplore, online resources, books as well as the author's own research and accomplishment.

To obtain project's goal the author used qualitative methodology. In other words, the interview conducted as a data collection and user testing for the project to understand how precisely users' feel regarding the contextual cues feature provided for two prototypes.

The report presents the seven principles of universal design of information and communication technology to the project with collaboration with simplicity and intuitiveness in design.

The essential of accessibility and usability in mobile interface design.

The best practices of design to implement a simple and more interactable mobile interface.

The research project compares two versions of mobile interface with and without contextual cues feature in order to learn and understand user's behavior as well as to measure how contextual cues feature is efficient.

Findings in this research illustrate that contextual cues feature in a mobile interface as a little box or as guidance is useful for users so that it makes value for them in interaction design. In other words, it makes way convenient for users to access hidden features in mobile applications.

Universally designed of buttons as well as color scheme used in the book reader and banking system applications were very satisfied by participants so that they reflected that they had not any difficulties or challenges to understand the functionality of the book reader application and banking system prototypes.

Research has given the author invaluable knowledge by reviewing different pieces of literature in human-computer interaction in interface design.

Additionally, research suggests that design for mobile interface based on seven principles of universal design has a profound effect on users' satisfaction so that designers and interaction developers should consider these principles to make more understandable and interactable products

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List of Acronyms

| | |
|------------------|---|
| Universal Design | UD |
| Contextual Cues | CC |
| ICT | Information and Communications Technology |
| DT | Design Thinking |
| UX | User Experience |
| UI | User Interface |
| HCI | Human Computer Interaction |
| SUI | Solid User Interface |
| GUI | Graphical User Interface |
| TAM | Technology Acceptance Model |
| ML | Machine Learning |
| DOL | Degree Of Interest |
| W3C | World Wide Web Consortium |
| DT | Design Thinking |
| SDF | Software Development Framework |
| WAI | Web Application Initiative |
| AI | Artificial Intelligence |

1. Introduction

As mobile applications and its features are diverse in this era the author of the presented report has become interested to conduct research on mobile interface design to understand interactive issues happens between mobile platform and users with the goal of producing an efficient solution in mobile interface design. In other words, make mobile interface more accessible, understandable, usable and simple for everyone with diverse range of abilities.

To demonstrate that the author explains Contextual Cues feature and its importance aim in mobile interface design. Moreover, to accomplish the presented feature there are two prototypes such as book reader application and banking system prototypes designed and developed by the author for the research project.

Contextual cues define as a guide or a style on the mobile interface to help users to find application's features more quickly and simply.

Contextual cues should be available during an interaction to reduce challenges that may cause inconsistencies to users during an interaction.

Contextual Cues shows as a little box on the left or right side of a mobile interface. The report will show how presented feature as a contextual cue locates by visual illustration.

The presented feature can make interaction much easier for users as it is available all the time on mobile interface. Therefore, people do not require to make effort or guess or challenge or try to predict to understand all developed hidden features belongs to a mobile application.

Contextual signal in mobile interface are frequently used to communicate functionality of application's feature.

Removing the need for user to guess or predict. For instance, on the web the underlining of text is commonly used to indicate a hyperlink, one or more of a different text color.

In addition, disabled functionality is commonly greyed out and do not react to the mouse to indicate that they are "inactive".

For more clarification, the responsibility of components in an interface design makes an issue clear that without the Contextual Cues feature, user will forever be guessing or making effort to find hidden features of a mobile phone application.

Contextual cues are a significant aspect of design since it communicates information to user on interface's behavior without the need for explicit instructions.

This form of communications is vital to modern mobile interface since users expect to work with instinctive applications.

As an example, contextual cues can be seen in some applications usually in the form of state changes or mouse-over changes or a tiny sign in mobile interface. For instance, Samsung Galaxy S8 plus has a feature with the name "Edge Panels".

The presented feature (Edge panel) is a form of contextual cues, allows users to communicate with all application's features as well as to access to features which are hidden in a mobile platform through a very simple way.

2. Literature review

As technology has become an integral part of people's life, the pervasive influence of portable devices such as, tablets, PDAs as well as smartphones are frequently augmented in day to day life.

In other words, methods in which digital technologies find themselves integrated into society are influenced to a significant degree by cultural conventions (Hwang, Guglielmetti, & Dziekan, 2015).

Digital technology are now ubiquitous in human's everyday life from moment to moment, while everyday events ground us in the world, our engagement and interactions with digital events are importantly occupied by digital technologies such as mobile applications, desktop applications as well as telecommunication services(Hwang et al., 2015).

The presence of portable devices such as smartphones have been witnessed in the recent decade. They pervade our daily lives, not only just in the form of feature phones, but also as smartphones and tablets.

“According to data released by StatCounter¹, 51.3 percent of all web visits in October 2016 came from mobile devices compared to 48.7 percent of visits from traditional computing platforms”(Antonelli, Watanabe, & de Mattos Fortes, 2018).

Tablets have been the object of much attention. They are set to be one of the fastest growing mobile device markets(Gonçalves, Carriço, & Magnusson, 2012) .They have the computing power of small computers. This is also true for the most advanced smartphones and mobile operating systems(Gonçalves, Carriço, & Magnusson, 2012).

We are in a situation of a fundamental change in how we relate to information and others, accessible at all times and places with the help of mobile devices (Gonçalves et al., 2012) .

Supporting user's navigation is an essential feature of mobile guides(Chittaro & Burigat, 2005).

Among the highlighted elements in the Web Content Accessibility Guideline (WCAG) navigation menus are the elements that cause the most impact for creating accessible content (Antonelli et al., 2018).

Human computer interaction known as HCI refers to learning systems that reduce user interface navigation and selection as adaptive UIs. Adaptive user interfaces automatically adjust content, layout, or visual presentation based on detected changes in device, context, task, or demands. They typically employ a user profile to personalize user experiences and to address user's needs (Yang et al., 2016).

In other words, supporting user's navigation is an integral goal of most, mobile guides, designing an interface that best fulfills the requirements of users is fundamental (Chittaro & Burigat, 2005).

The presented issue is challenging since, besides limitations of mobile devices, one must consider that navigation is often not the primary task for the user and thus cognitive resources required to use the guide should be limited(Chittaro & Burigat, 2005).

Many mobile guides have route planning information for wayfinding to users. In addition, specific mobile guides has been developed to provide information and navigation assistance for mobile users (Chittaro & Burigat,

2005). For instance, in public museums, public transportation, or even to support people's social lives.

Artificial intelligence as, this change might be barred to an enormous number of people, suffering from a wide range of disabilities (Gonçalves et al., 2012).

Mobile devices are increasingly visual, making them hard to use by the blind or other vision-impaired people. Keyboards are steadily being replaced by touchscreens, without tactile feedback, introducing additional barriers.

Paraplegic users (someone who is unable to move the lower part of their body such as their legs) have limited mobility of their limbs and hardly are able to pick up the devices or use their fingers for precise pointing (Gonçalves et al., 2012).

Additionally, mobile devices are being used as mediators to reach digital interfaces (e.g. interactive TV, information kiosks, etc.) providing people with disabilities with the means to potentially overcome physical barriers and freely interact with the environment (Gonçalves et al., 2012).

Mobile devices are ubiquitous and there are still improvements that should be considered to figure out problems in interface design in terms of accessibility, usability, simplicity and intuitiveness (the 3rd principle of UD-ICT).

It is crucial to improve the visibility of interactional aspects of interface. In other words, users should be able to clearly distinguish and aware that through assistive features during an interaction with portable devices such as mobile phones.

In real human face-to-face conversation, people take turns to speak and give cues like back-channeling cues to express various emotions. Back-channeling cues specifically are used as an expression of consent or sympathy by the listener in a conversation and help make the speaker lead the conversation more smoothly (Lee & Lee, 2018).

In text-based environment, communication becomes more challenging. Back-channeling cues cannot be presented like the way natural human communication occur, because it is difficult to express emotions through texts.

many existing studies suggest that even in text-based environment, the users can find a way to express emotions (Lee & Lee, 2018). Moreover, through continuous trials and changes, users in text communication environment develop a socially accepted paralinguistic cues to substitute the absence of nonverbal cues (Lee & Lee, 2018).

Mobile computing has some different aspects of unique challenges for user interface design. User interface must now accommodate the capabilities of various access devices and be suitable for different contexts of use, while keeping consistency and usability (Eisenstein, Vanderdonckt, & Puerta, 2001).

Since the lack of multimodal communication in mobile applications are exist, users have learned to avoid these limitations creatively by using e.g. emoticons to explicitly express mood states in textual messages (Heikkinen, Rantala, Olsson, Raisamo, & Surakka, 2011).

In addition to multimodal communication, machine learning (ML) has become an attractive and effective scientific study for improving mobile user experience(Di Mitri et al., 2017).

Using a machine learning approach on multimodal data such as heart rate, weather conditions and learning activity can be used to predict learning performance in self-regulated learning system(Di Mitri et al., 2017).

Mobile user interface particularly benefits from adaptations that reduce navigation and selection efforts since mobile tasks and contexts vary from small screens limit interaction and content space and the usage limits attention making every second count. For instance, Starbucks application might understand/learn the way users pay money for their desire drinks with their mobile phone. This happens when people land on the Starbuck's application payment screen on their mobile phone in Starbucks store(Yang, Zimmerman, Steinfeld, & Tomasic, 2016). Moreover, adaptive interfaces also benefit users with disabilities (Yang, Zimmerman, Steinfeld, & Tomasic, 2016).

Yang presented that these users pay a higher cost to navigate user interface in terms of cognitive and physical effort.

Liu (2014) reported that a good user interface is artistic and understandable with easy manipulation and guideline which enhances users' emotions and motivations in mobile interface.

The most important user interface (UI) techniques is to display information within context (focus + context) are Fisheye views and Degree-Of-Interest trees known as DOI trees (Laqua & Sasse, 2009). Both techniques have

found a range of applications in scientific and mainstream scenarios (Laqua & Sasse, 2009).

The contextual user interface tries to improve orientation on information spaces and facilitate more explorative interaction strategies (Laqua & Sasse, 2009). In addition, most of the existing focus plus context implementations only work on linear information spaces or require well-defined information structures so that many implementations try to display as much context as possible. This achievement of contextual information can help to understand the large structure, relationships and to get a general overview (Laqua & Sasse, 2009).

Displaying too many links simultaneously for a large number of information can cause visual noise or problems (Laqua & Sasse, 2009). Therefore, too many diverse displayed elements make information overload within a context itself. On the other hand, presenting less information in a context relevant to an individual user might provide easier access and a more understandable information experience (Laqua & Sasse, 2009).

Mobile and wearable devices place an enormous restriction on input and output as well as on user attention. Information management is becoming increasingly difficult and complex in the mobile environment. People should challenge a multitude of dynamic sights, sounds and other stimuli that convey information and compete for their limited attention (Campbell & Tarasewich, 2004).

Mobile applications can have a significant number of objects and activities competing for a user's attention aside from application or device itself so that it can be confusing and unmanageable (Campbell & Tarasewich, 2004).

A good mobile notification design should completely inform users on a small form factor without requiring many attention and training (Campbell & Tarasewich, 2004).

A well-designed product is accessible to users of all abilities, including, low vision, blindness, hearing impairment, cognitive and motor impairment. Therefore, improving product's accessibility enhances the usability of all users(Campbell & Tarasewich, 2004).

The interface can support users with appropriate interaction and presentation capabilities and avoid unnecessary actions of the user to change the mobile interface since the interface can automatically adapt to a user's need(Leichtenstern, Erdmann, & André, 2008).

Appropriate services must be provided by the mobile interface to complete tasks and succeed a user's main goal(Leichtenstern et al., 2008).

Interaction and presentation consist of regulation for adaptation of the interface to meet main and situational goals. The user can trigger context by interacting graphical user interface which is usually textual-based or menu-based(Leichtenstern et al., 2008).

In case a user has triggered graphical user context the user interface can be adapted to a variety of displays. For instance, by displaying another screen and playing a sound signal (Leichtenstern et al., 2008).

User interface called human-machine interface is the manipulate interface between users and machines(Liu et al., 2014). A mobile phone usually has two types of user interfaces which are solid user interface known as SUI and software interface(Liu et al., 2014).

In addition, SUI called as entity interface that can be touched, seen and sometimes felt(Liu et al., 2014). keys and screens involved in this type. In addition, what screen reflects mainly depends on the software interface which means graphical user interface known as GUI (Liu et al., 2014).

User interface style is an important aspect of design which should be considered during design sprint. Interface style treated as an external factor in TAM known as Technology Acceptance Model (Li & Wang, 2014).

To examine its effects on behavior intention to accept and use a system finding illustrated that interface style had a direct effect on behavioral intention to use the system (Liu et al., 2014).While interface style is related to a satisfactory user experience.

Based on interview records, conducted by (Liu et al., 2014) demonstrates that five factors are considered by users in user interface so that those are as follows:

1. Color matching
2. Message layout
3. Personal style preference
4. Aesthetics of interface
5. Information comprehension

These five factors not only cover usability and aesthetics together. In addition, it covers personal attitude as well (Li & Wang, 2014).

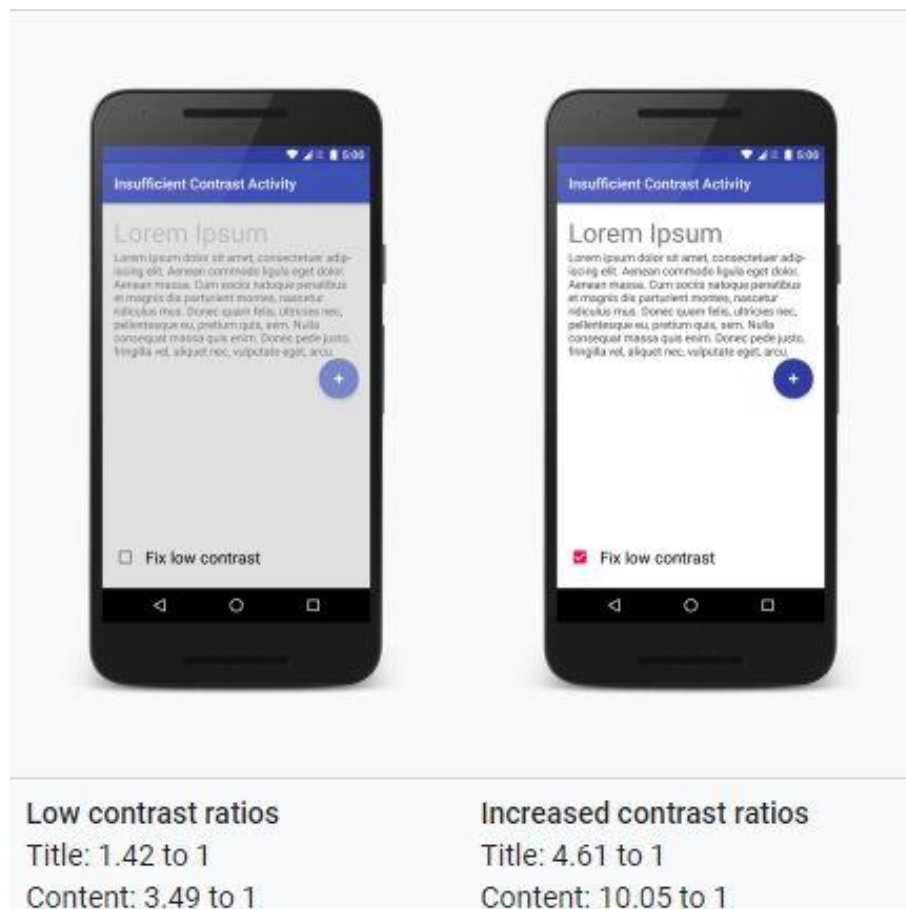
The design process is moving away from silos of engineering and development into the participatory design (Mullins, 2015).

Interfaces make opportunities for users to personalize their interaction. For instance, modifying colors, typeface, and type size of an interface. They can relocate the content box of the screen based on their preferences. For example, hiding and surfacing digital content, adding personal details so that this level of user customization and personalization is a reality in many designs (Mullins, 2015).

Color contrast in the user interface is another factor that should be considered during an interaction design. People with low vision and who uses a device with dim display might have difficulties reading the content on the screen. by providing increased contrast ratios between foreground and background colors in mobile applications you make it easier for users to navigate between the screens.

Figure one shows the differences between low contrast and high contrast in a mobile application.

Figure 1: Example of low and increased contrast ratios between foreground and background colors



For large text, 18 points or higher for regular text and 14 points or higher for bold text, you should use the contrast ratio for at least 4.5 to 1

For small text, smaller than 18 points for regular text and smaller than 14 points for bold text, you should use a contrast ratio of at least 4.5 to 1 (“Accessibility,” n.d.).

Accessible media content is a factor that should be considered in the interaction design. In other words, users with different type of ability and needs should have capable hands to work with materials used in contents.

For instance, video and audio content should have controls that allow users to pause, stop and play (“Accessibility,” n.d.).

Indicate elements should use action verbs to present what an element or link does, not what an element looks like. Therefore, visually impaired users can fully understand.

Picture below shows the mentioned issue by two illustrations.

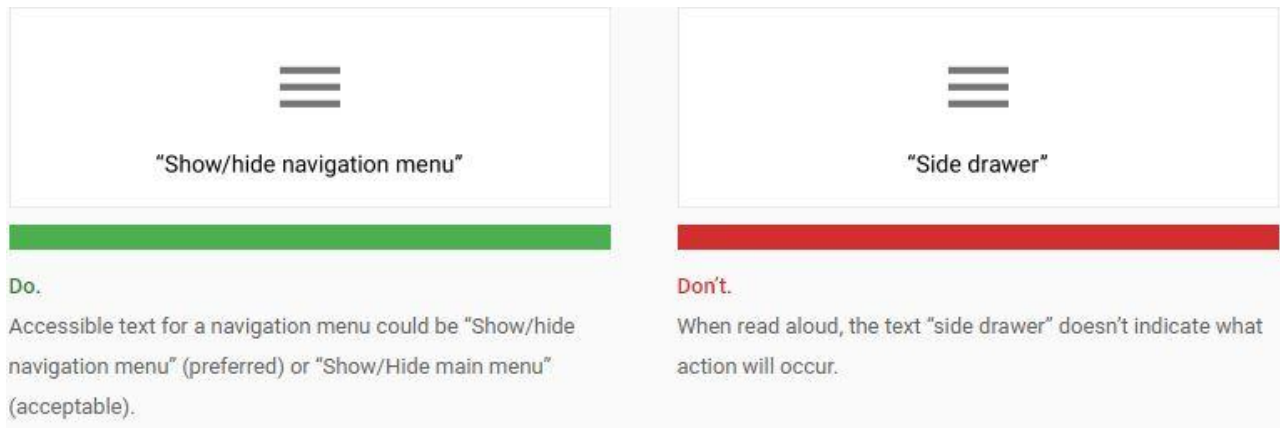
Indicate what an element exactly does

Figure 2: Indicate what an element does



Another example is in below illustration

Figure 3: Indicates Functionality of navigation menu

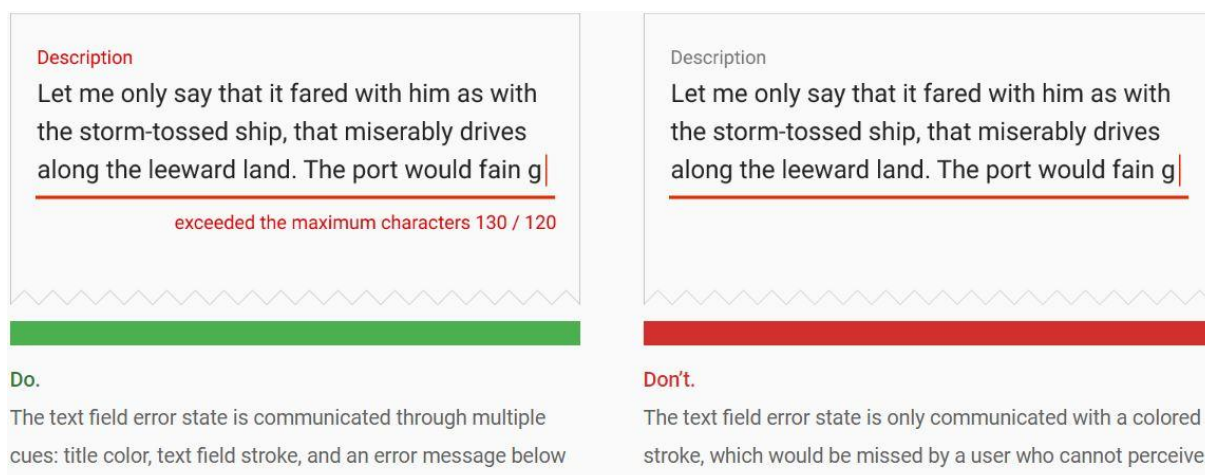


Use action verbs to show what an element or link exactly does. This means that do not tell users how physically interact with the control because they may be navigating with a keyboard or other devices, not with their fingers or a mouse. Accessibility software will describe the correct interaction for users.

Visual cues should be understandable for everyone. In other words, for users who are colorblind and cannot distinguish between colors. As colorblindness includes different forms such as red-green, blue-yellow and monochromatic it is better to use multiple visual cues to communicate important states. Using element such as indicators, patterns, texture or text to describe actions and content ("Accessibility," n.d.).

Picture below gives an example of the presented problem.

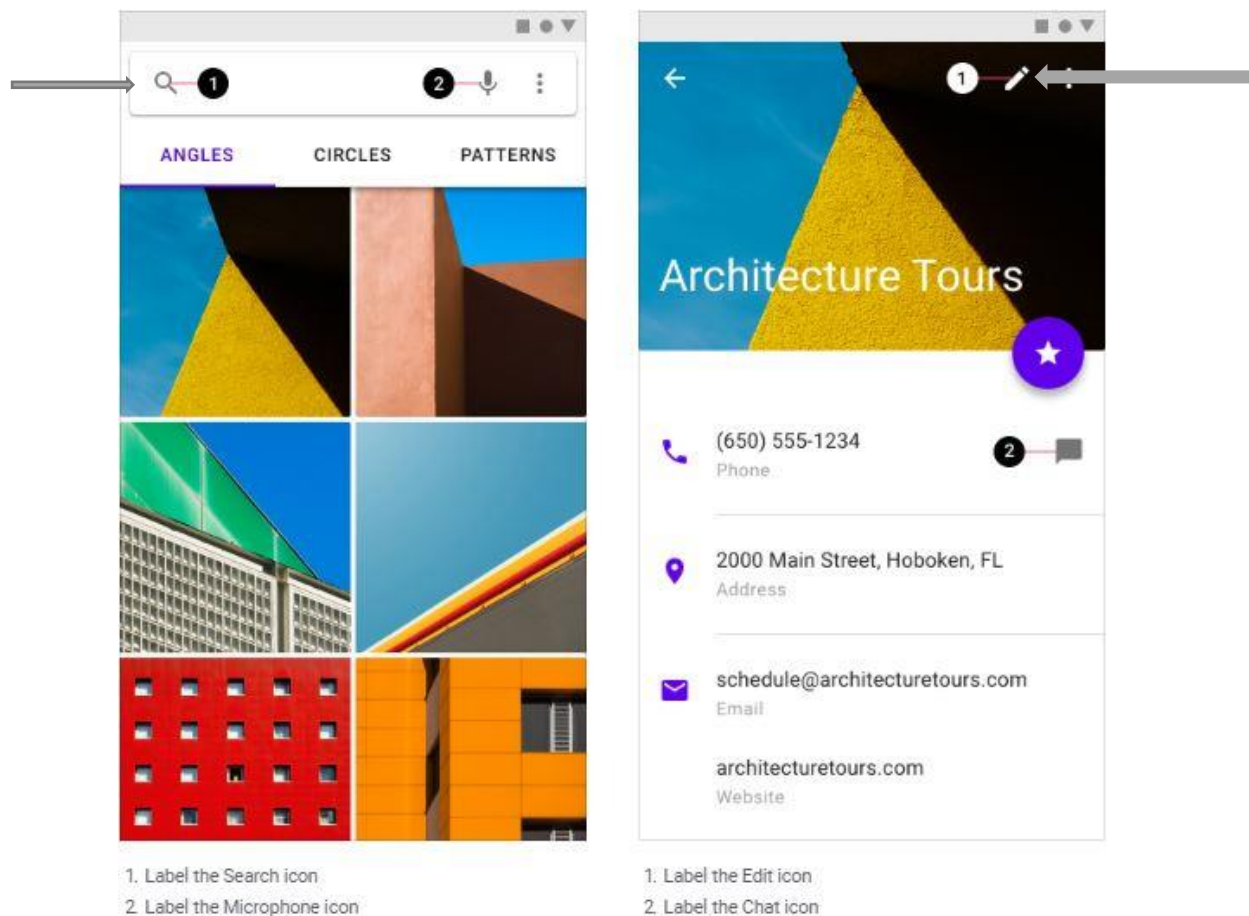
Figure 4: visual cues



Screen reader users need to know functionalities of each items in a user interface design. In addition, they need to know which user interface elements touched by their finger when screen reader reads component's functionalities out loud. To accomplish the mentioned goal, designers should add content description attribute to some components such as buttons, Icons and tabs containing icons that have no visible text.

Figure below shows that there are two numbers with black color which presents two different elements on the user interface. For instance, number one refers to search element and number two refers to voice search element. Therefore, pointing elements by numbers (such as 1 and 2 in the picture below) allows screen reader application to simply read any content in mobile interface and reflect it to users by sound. ("Accessibility," n.d.)

Figure 5: Labeling user interface elements for accessibility



Contrast ratio represents how different a color is from another color written as 1:1 or 21:1.

The higher the difference between two numbers in the ratio, the greater the difference in relative luminance between the colors (“Accessibility,” n.d.).

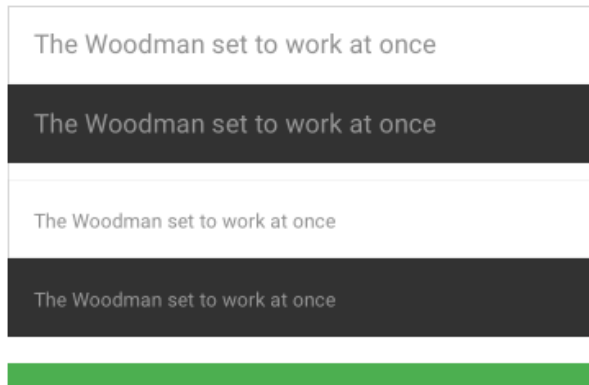
According to W3C recommendation the following contrast ratios for body text and image text should be considered.

Small text should have a contrast ration of at least 4:5:1 against its background (“Accessibility,” n.d.).

Large text should have a contrast ration of at least 3:1 against its background.

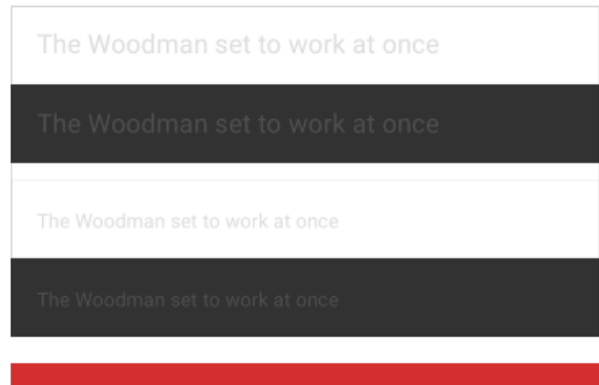
Figure 6 presents the mentioned issue by two illustrations.

Figure 6: Contrast Ratios



Do.

These lines of text follow the color contrast ratio recommendations and are legible against their background colors.

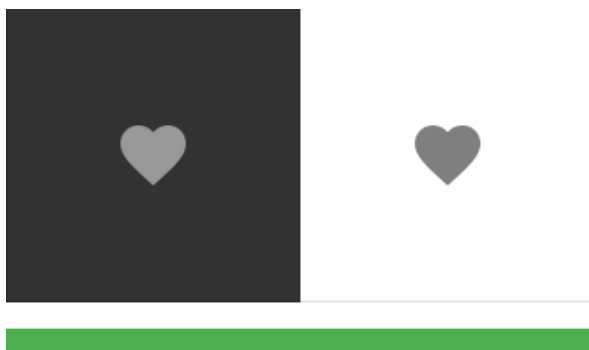


Don't.

These lines of text don't meet the color contrast ratio recommendations and are difficult to read against their background colors.

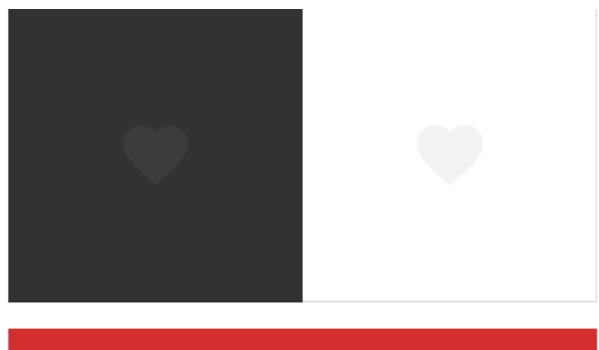
The mentioned regulation is same to show logos and critical elements.

Figure 7: Icons and critical elements



Do.

These icons follow the color contrast ratio recommendations and are legible against their backgrounds.



Don't.

These icons don't follow the color contrast ratio recommendations and are difficult to discern against their backgrounds.

Based on cognitive science literature, human memory is predicted on contextual cues in the environment (Hailpern et al., 2011). For instance, room and music. However, computer systems do not influence human's natural process of using contextual cues to facilitate remembering (Hailpern et al., 2011).

Hailpern reported that a user may remember the song that was playing in a website, their physical location, a phone call that interrupted them, or even files or websites that were open at the same time. These temporally activities are referred to as contextual cues.

Contextual cues are a key components of human memory (Hailpern et al., 2011).

We can define contextual cues as any event that has a temporal relationship to a search target. For instance, consider a Twitter message that a user sends while working on a document, if he searches for that Tweet in order to locate his document the Tweet is a contextual cues (Hailpern et al., 2011).

While using contextual cues is a natural method of remembering, modern computers (and their extensive search applications) do not yet support this form of contextual search. Moreover, research in cognitive science has shown that the action of context improves speed and accuracy in remembering task (Hailpern et al., 2011).

For example, a personal file history search is limited to file metadata (e.g., file name, last date accessed, file size, file type and sometimes file content) so that if a user does not know this information, he cannot search for and

find a file. Moreover, without a form of contextual search , users do not have power the natural process of remembering (Hailpern et al., 2011).

we do not know how ubiquitous desire for contextual search on computers is, because modern systems do not support it. Therefore, working from theoretical background on memory, result in search based on contextual cues will enhance remembering and computer usability (Hailpern et al., 2011).

Human Memory and Contextual Cues

Hailpern reported that, “It would be hard to overstate the importance of understanding the profound influence of environmental context on human memory”

Human memory functions by activating these contextual cues(Hailpern et al., 2011).

The probability that the human mind recalls a piece of information is a function of the strength of the association between the context used for recall, and the target information (Hailpern et al., 2011).

Therefore the richer the set of contextual cues available to an individual, the higher the probability of successful recall (Hailpern et al., 2011).

The importance of user experience

Why does user experience is important? User experience is something that all ubiquitous (Mullins, 2015).

In other words, they all experience a user has when using an application, service or a system. It is not just about designing a website or mobile application so that it is beyond that.

User experience and usability are as encompassing all aspects of the end-user's integration with the company such as its services and products (Mullins, 2015).

The user experience has evolved through a several iterations. In other words, from the early days of ergonomics and Human computer interfaces to an emphasis on visual aspects of design (Mullins, 2015). In addition, to an architectural focus and to a focus on usability and user centered design (Mullins, 2015).

Finally, a more holistic approach of user experience are usable, useful and desirable. (Mullins, 2015).

Design Thinking is a user-centered model and it is focused on creativity and innovation to create a product, service which solves complex problems for the target customer(Nedeltcheva & Shoikova, 2017).

Design thinking is more problem-solving matter, big-idea process and it is more strategic theory (Nedeltcheva & Shoikova, 2017).

UX is based on user's experience or digital experience and is doing empathic (expressing an opinion, idea in a clear, strong way to show its importance) research to assist the problem to solve, find steps to innovate and is used to continue designing, testing, iterating and building a product or service more appealing and efficient to people(Nedeltcheva & Shoikova, 2017).

The two methodologies are almost very similar, but the collaboration aspect of design thinking is not always done in the UX process in practice(Nedeltcheva & Shoikova, 2017).

Figure eight illustrates that the five essential steps in design thinking.

Figure 8: Design Thinking Model



Nedeltcheva & Shoikova, (2017) reported that IBM Design Thinking activities are divided into two main phases.

The visioning phase is responsible for develop software requirements through the use of several design thinking practices that combines user personas, empathy maps, hills and story maps (Nedeltcheva & Shoikova, 2017).

The other phase is the delivery wave which consists of software development sprints conducted by multidisciplinary teams that includes sponsors users,

who contribute with constant feedback about the delivered artifacts?

IBM design thinking are as follows (Nedeltcheva & Shoikova, 2017):

- Diverse empowered team
- A focus on user outcomes
- Restless reinvention
- Think out of the box or see problems and solutions from a new point

of view.

At the heart of IBM design thinking is a behavioral model for understanding users' needs and envisioning a better future. In other words, a continuous loop of observing, reflecting and making (Nedeltcheva & Shoikova, 2017).

Lauesen reports (2005) "usability consists of six factors:

- 2.1. Fit for use:** in other words, system can support the task that the user has in real life.
- 2.2. Ease of learning:** how easy is the system to learn for diverse groups of users?
- 2.3. Task efficiency:** how efficient is it for the frequent users?
- 2.4. Ease of remembering(recall):** how easy is to remember for the occasional user?
- 2.5. Subjective satisfaction:** how satisfied is the user with the system?
- 2.6. Understandability:** how easy is to understand what the system does? It is specifically important in unusual situations. For instance, error situations or system failures" (p.9).

When developing interactive software system a key quality factor is usability of software for its prospective users (Høegh, 2006). In other words, usability evaluations are applied to assess the quality of the use interaction design and establish a basis for improving it (Høegh, 2006).

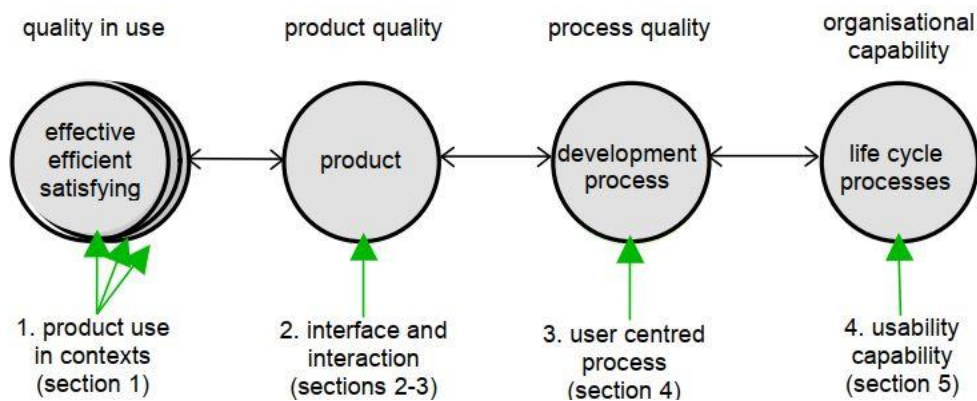
In addition, usability is a fact that making products and systems easy to use and easy to understand. Matching them more closely to users' need and requirements.

When it comes to the goal of the presented project it is pretty evident that to measure to what extent the contextual cues feature is useful during an interaction in mobile interface. Therefore, during design process the author of this report thought directly about usability, simplicity and intuitiveness for the project (the third principle of universal design standard) of use based on the usability factors.

The objective of designing and evaluating systems, products and services for usability is to enable users to achieve goals such as effectiveness, efficiency and satisfaction, taking account of the context of use (“ISO 9241-11:2018(en), Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts,” n.d.).

Picture below shows the logical relationship: the aim is for the product to be effective, efficient and satisfying when used in the intended context

Figure 9: steps to produce usable products



Ghaoui, (2006) reported that, there is a prerequisite for the presented steps which is an appropriate interface and interaction. In other words, it requires

a user-centered-design process accomplished consistently requires an organizational capability to support user centered design.

In order to achieve usability goal, the interaction designers must understand who users are, what the goal they are looking for or what they want to achieve when they use application.

Understanding of users' profile has a profound effect on user research. In addition, it is great to mention that during design thinking process a designer should not think about a specific user or an age group. For instance, age between the range of twenty or forty.

Interaction designers should think more broadly and think about everyone. Therefore, the main point is that to think what the core functionality of an application is about and the second one is that to investigate users' profile.

By the mentioned solution interaction designers has become capable to continually reevaluate questions during design thinking process.

Another question that system designers or interaction designers should be able to consider is thinking about a question such as: am I being consistent? In other words, when they are designing a mobile interface or a web system they should continually think about consistency of use. For instance, they should ask themselves, is my design consistent with my brand?

2.1. Project's research question.

To figure out project's goal I have formulated my research question so that it is as follows:

- Do contextual cues feature in mobile interface have a positive effect on accessibility on mobile platform and makes interaction between a human and a mobile phone more simple, understandable and robust?

To reach the presented approach I have designed and developed two prototypes and I have tested them with diverse group of users from different age groups as well as different range of abilities. The participants were consisting of people from 18 to 51 years old. I have tested my prototypes with and without contextual cues feature independently to get clear feedback from them(participants).

In order to test my research question, I have made a test plan with a few questions inside so that those questions are as follows:

1. Who am I testing for?
2. What are the most popular devices users may use during an interaction on mobile platforms? For instance, iPhone and Samsung products or other third-party products such as Windows phone, etc.
3. Where they use the product?
4. What time is suitable for doing test?
5. What difficulties may participants experience during an interaction?

Moreover, conducted usability testing to realize that navigation, content and task success are working accurately or not. Usability testing such as user survey to ensure that the ease of effectiveness and satisfaction are exists in the product or not. For instance, users can work with the application's content easily without contextual cues or not? How long does it take to find features located behind the screen (hidden features)? In other words, whether Contextual Cues feature is invaluable in user interface design or

not. What kind of inconsistencies may users encounter during an interaction to find the hidden features?

Do they satisfy, angry or frustrated with the contextual cues? If they are not satisfied what prevent them to success and make satisfaction for them.

These are questions I made and tried to get answers from my users who participated in the research study. Moreover, the result of user's feedback and analysis has been reflected in the result and analysis section of the document.

In the next part I am describing the prototypes and their functionalities besides the contextual cues feature located on the user interface of the prototypes.

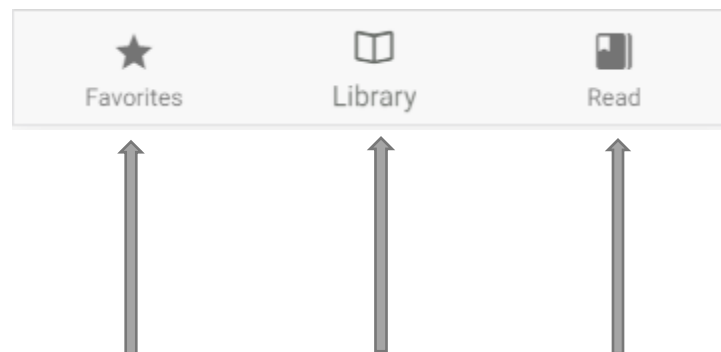
3. Design and development

First prototype designed and developed for the research project is a book reader mobile application, designed by Ionic framework, uses JavaScript programming language. By using this application user can review a list of books in the library section of the application and choose range of books based on subjects they are interested to read.

The presented application consists of three tabs in front of the user interface in the bottom of screen. Therefore, the name of each tabs as follows:

Favorite, Library, Read.

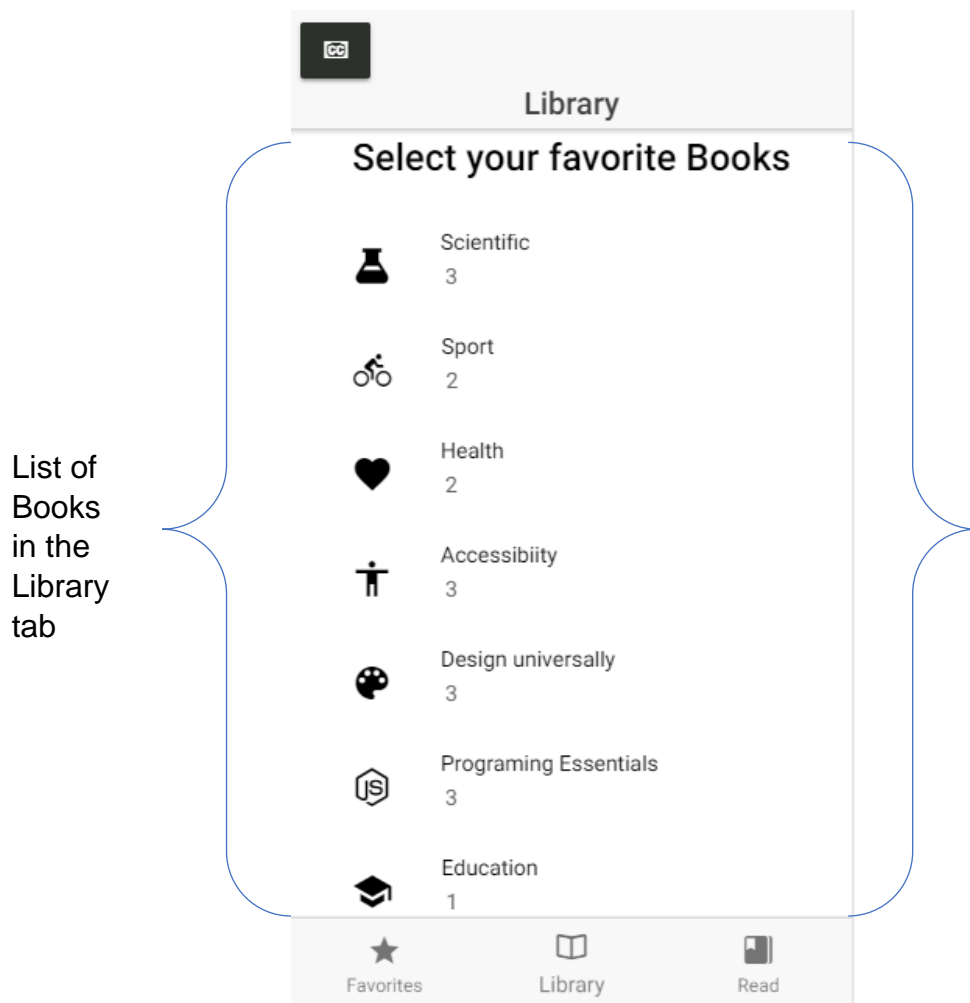
Figure 10: book reader interface tabs



3.1. Functionality

The Library tab is a landing page of the application which has seven categories of books selectable by users. Thus, users can read the list and select their favorite book from the list. Picture below shows the list.

Figure 11: Library tab content



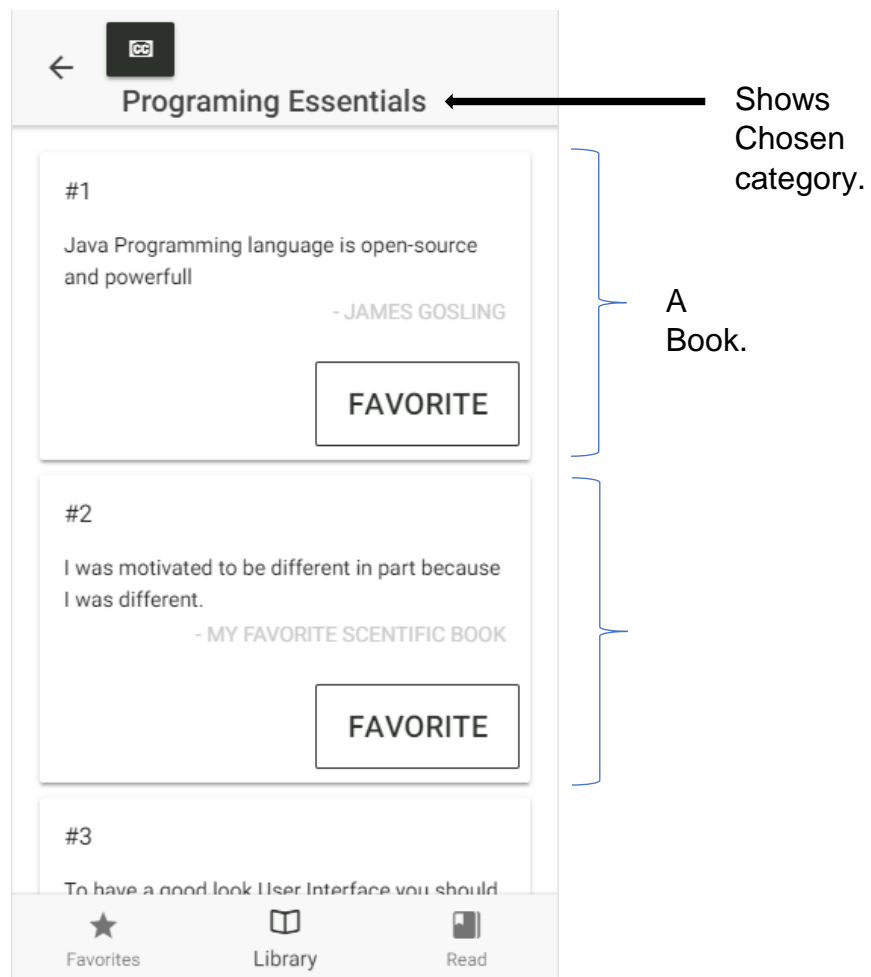
These are list of books located in the library tab. The data located in the list are hard coded as a dummy data so that the title and the content of each book are a JSON array which is developed in the structure of the

application.

In 'Favorites' page user can access to their favorite list of books. The list involves items which users picked form the library list. In the 'Read' page users can read their desired book.

Picture below shows three different books which was selected by a user.

Figure12: one category



3.2. Color in user interface design

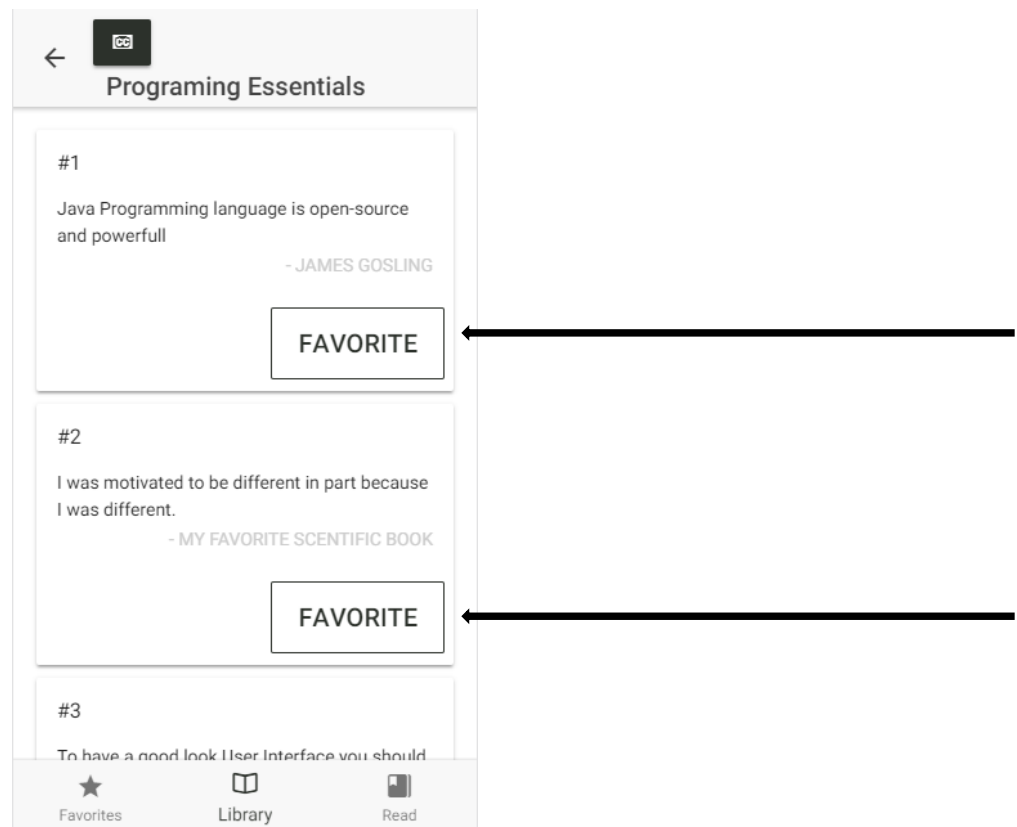
Buttons in the presented application designed in large size with the white background and black foreground wrapped by the black rectangle.

Therefore, it makes way simpler for target users to easily navigate, understand and read.

Moreover, diverse users with different range of abilities and understanding can read and understand. In other words, users such as visually impaired and color-blind can benefit with the styles of buttons (refer to equitability of universal design principle) as design and color scheme is very simple.

Picture below shows the style of buttons

Figure 13: the style of buttons



Descriptive text related to each symbols, icons and buttons is an essential factor in design that should be considered by interaction designers and web designers since it makes user interface more understandable and clear. Thus, target users can simply read and figure out the functionality of each buttons, icons and symbols located in a user interface.

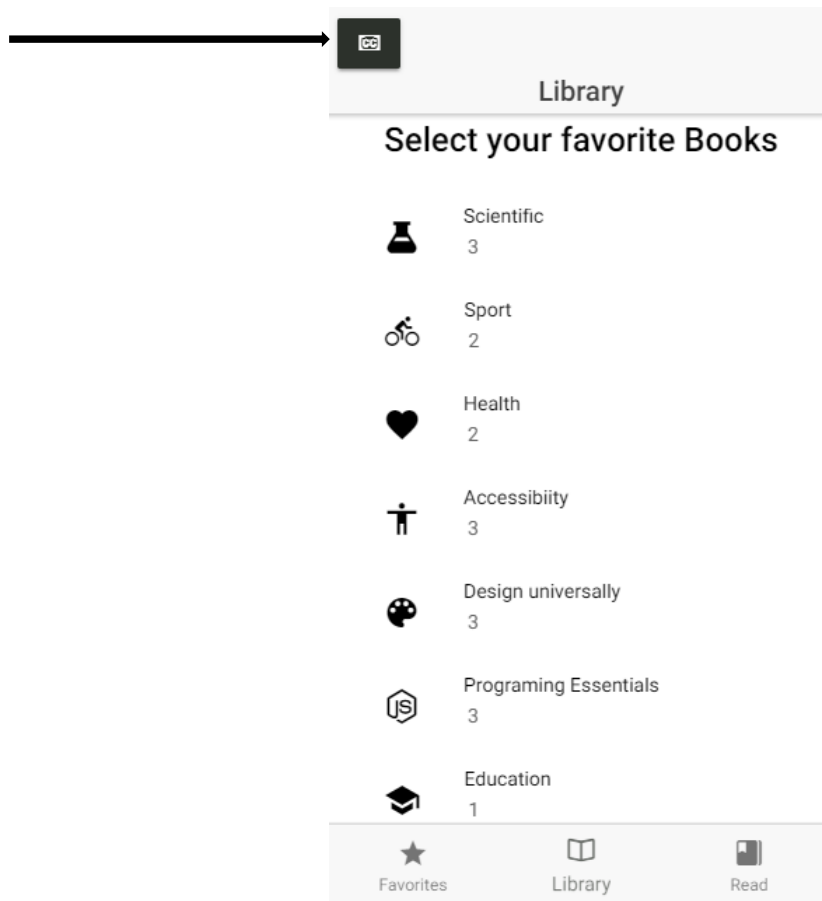
In the presented application the tab bar (Favorites, Library, Read) has descriptive text with the goal of informing users about the functionality of each tab.

3.3. Contextual Cues feature on mobile interface

The Contextual Cues button designed and developed by the author of this report is a tiny button with a black background and a text CC inside to the black box which is located on the top left corner on the screen.

Picture bellow illustrates the Contextual Cues button.

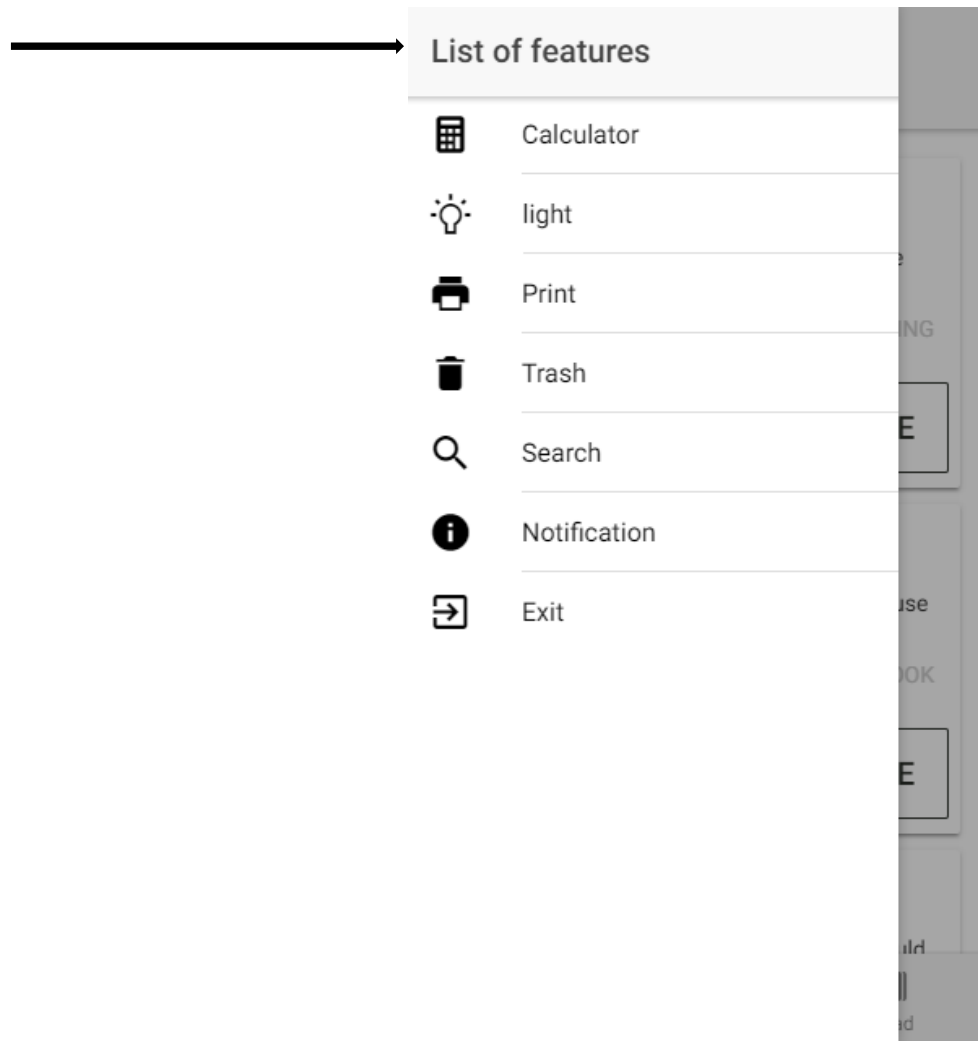
Figure 14 the Contextual Cues



The Contextual Cues feature is available during interaction in all pages of the application in order to introduce list of hidden features in the application. Therefore, those features are not accessible with the absence of Contextual Cues.

Picture below illustrates the list of hidden features.

Figure 15 List of Hidden Features



As the illustration above presents access to the list is not possible without the presence of Contextual Cues feature in the application. The Contextual Cues feature allows users to access to feature that are hidden entirely in the application. Therefore, in this situation a question arises as to how it is possible for users to know that these features are available?

3.4. Technical discussion in development

As I mentioned earlier in the document the presented application uses Ionic framework which has been written by JavaScript programming language.

Ionic is a complete open source software development kit for hybrid mobile application created by Max Lynch, Ben Sperry as well as Adam Bradly in 2013 (“Ionic (mobile app framework),” 2019).

This software development kit was released on the year 2013 and built on top of AngularJS and Apache Cordova (“Ionic (mobile app framework),” 2019).

Ionic framework uses NodeJS technology which is the JavaScript run time environment for designing and developing client-side and server-side web and mobile applications. In other words, NodeJS is a dependency for the Ionic framework so that without its present development with Ionic framework is not possible. Appendix C describes more in detail.

The contextual cues feature designed for the project is a form of button element which has been written in the core structure of the application.

Picture below shows the code structure developed to build the Contextual Cues feature in entire application.

Figure Contextual Cues code structure

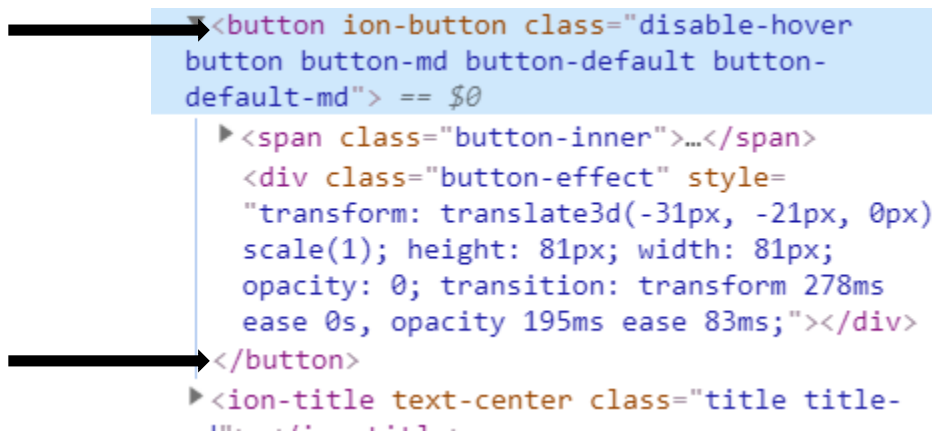
```
<button ion-button (click)="onOpenMenu()">  
  <ion-icon name="closed-captioning"></ion-icon>  
</button>
```

As I mentioned earlier this application has three pages such as Favorite, Library and Read. Therefore, in order to put this feature in all pages of the

application the presented code must be hard coded in all pages on the application structure.

Picture below illustrates that the compiled code by the JavaScript's compiler so that the result of compiled code appears in a browser same as below picture.

Figure contextual cues - Contextual Cues compiled code structure

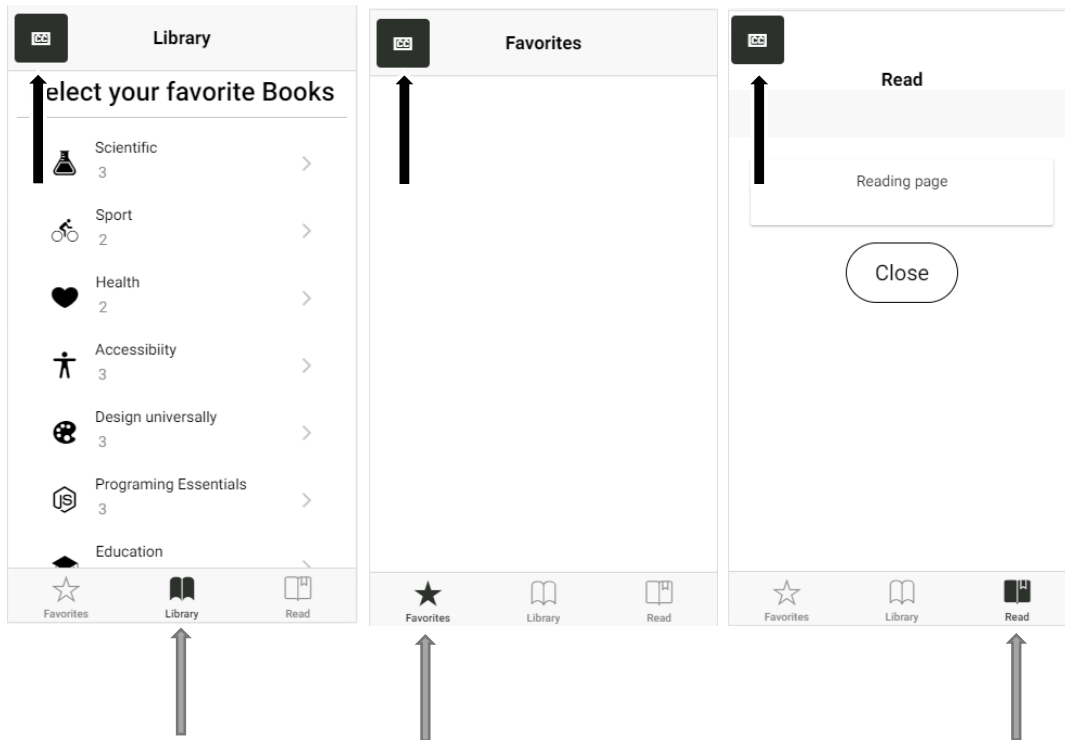


```
<button ion-button class="disable-hover  
button button-md button-default button-  
default-md"> == $0  
  ><span class="button-inner">...</span>  
    <div class="button-effect" style=  
      "transform: translate3d(-31px, -21px, 0px)  
      scale(1); height: 81px; width: 81px;  
      opacity: 0; transition: transform 278ms  
      ease 0s, opacity 195ms ease 83ms;"></div>  
  </button>  
  ><ion-title text-center class="title title-  
  ... ..
```

This button is available in all pages of the application in order to make possible to access to the hidden features of the application.

As a result, we can see the Contextual Cues in all pages in the application.

Figure All pages at the same time with the Contextual Cues feature



4. A summary of mobile accessibility guideline presented by W3C

WCAG stands for Web Content Accessibility Guideline which was announced by W3C the web consortium with the goal of making Web content accessible for everyone.

Although, the World Wide Web Consortium (W3C)'s Web Accessibility Initiative (WAI) is primarily concerned with web technologies and guidance for web-based technologies. It is often relevant to non-web technologies such as Mobile devices and tablets as well. ("Mobile Accessibility," n.d.).

The W3C-WAI has published the note guidance on applying WCAG 2.0 to non-web Information and communications technologies (WCAG2ICT) to provide authoritative guidance on how to apply WCAG to non-web technologies such as mobile applications ("Mobile Accessibility," n.d.). Moreover, there are four principles for the mentioned guideline so that they are as follows:

1. Perceivable
2. Operable
3. Understandable
4. Robust

In addition, all steps have a conformance level such as A (the minimum level of conformance), AA (a design satisfies all the level A as well as level AA) and AAA (a web page satisfies all the level A, AA and AAA criteria) shows a standard that a design on both platform Web and Mobile meet to

satisfy the requirements of the standards (“Understanding Conformance | Understanding WCAG 2.0,” n.d.).

4.1. Perceivable:

Small screen is one of the most important aspect of a mobile devices. The small size of the screen makes practical limits on how much information people can view at one time, specifically when low vision people uses magnification to view mobile content.

Perceivable in this context means amount of information which are exists in a page on mobile interface should be minimized compared to desktop version of the application. The goal is to make content simpler and more understandable for the target users. For instance, positioning form fields such as Zoom or Magnification below rather than beside their labels. This is good practice in portrait layout.

For further information I will describe the seven principle of universal design standard.

It is great to mention that universal design of ICT introduced seven principle so that those are as follows (“The 7 Principles | Centre for Excellence in Universal Design,” n.d.):

1. Equitable use
2. Flexibility in use
3. Simple and intuitive use
4. Perceptible information
5. Tolerance for error
6. Low physical effort
7. Size and space for approach and use

The author thought about these principles during design and development of two prototypes. For instance, the principle number three is evident in the Book reader application because of forms of buttons and the chosen color scheme. Therefore, as all icons has a descriptive text so that users can easily understand the functionality of each button. In this case the application meets principle number four the perceptible information.

Moreover, the low physical effort has been met since the shape and size of buttons designed big enough to cover diverse type of fingers and touches.

In banking system prototype the tolerance for error is evident as the functionality of the prototype is simple and understandable for target users.

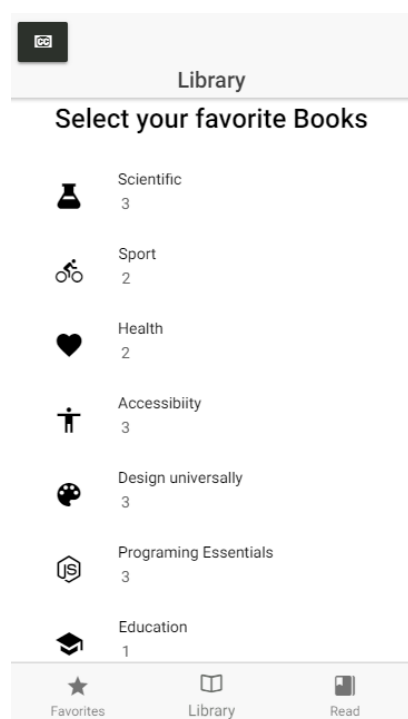
In my prototype items in mobile version has been designed much bigger compared to desktop or tablet version.

Picture below shows two different views of the application.

Figure WCAG_1: The desktop view of the application



Figure WCAG_2: Mobile portrait view



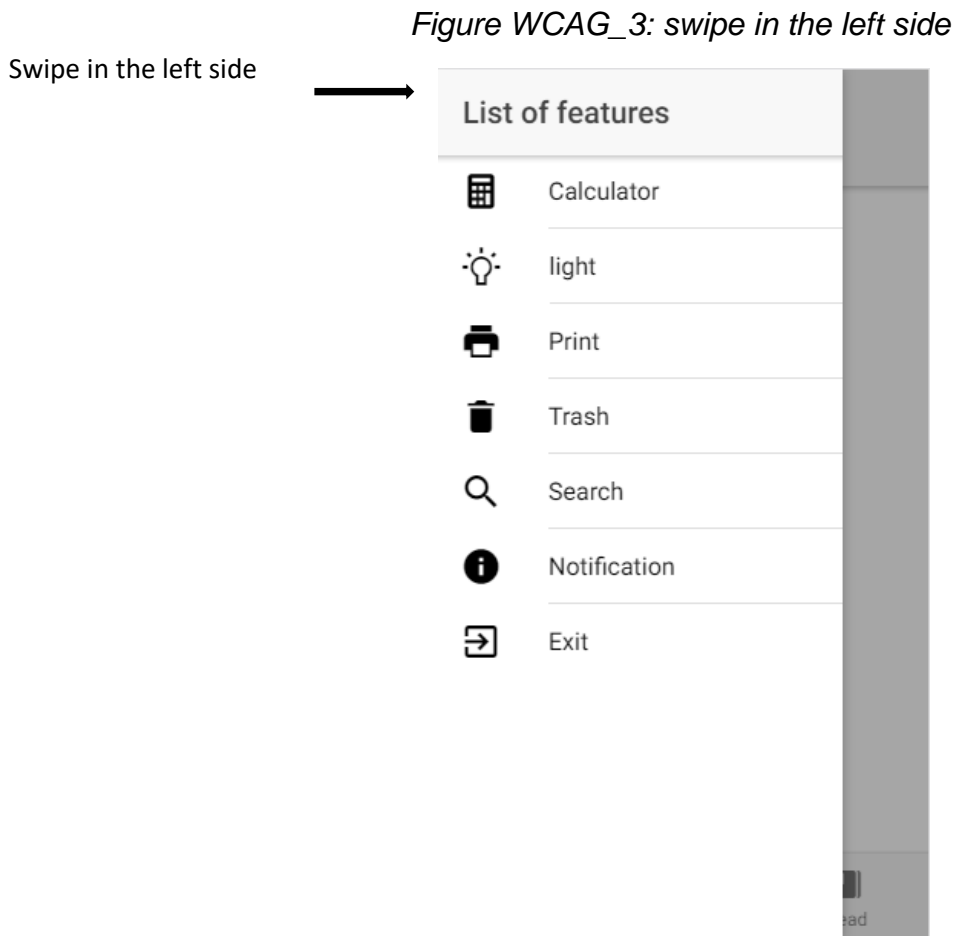
Contrast rating is another factor which is important in this section. As mobile devices are more likely than desktop or laptop devices is used in varied environment. Therefore, Mobile device might be encountered a few issues such as screen reflection from the sun or glaring from strong lighting. As a result, contrast ratio becomes an important factor in this case which should be considered by interaction designers.

4.2. Operable:

As mobile devices have evolved away from having physical built-in keyboard. However, keyboard accessibility becomes an important factor that should be considered by designers and developers. In addition, factors such as touch target size and spacing as well as touchscreen gesture and the place of buttons are factors that they need to be taken a consideration during design. For instance, a swipe in from the left side of the screen

gesture to open a menu is not discoverable without an indicator or advisement of the gesture (“Mobile Accessibility,” n.d.).

In this context I can refer to the contextual cues feature shows as an indicator or advisement of the gesture for target users. Figure below shows when users swipe the screen from left side of the mobile screen to the right side of the screen



Overall, operable means mobile devices should be workable in physical point of view for all people with diverse range of abilities based on presented factors in this section.

4.3. Understandable:

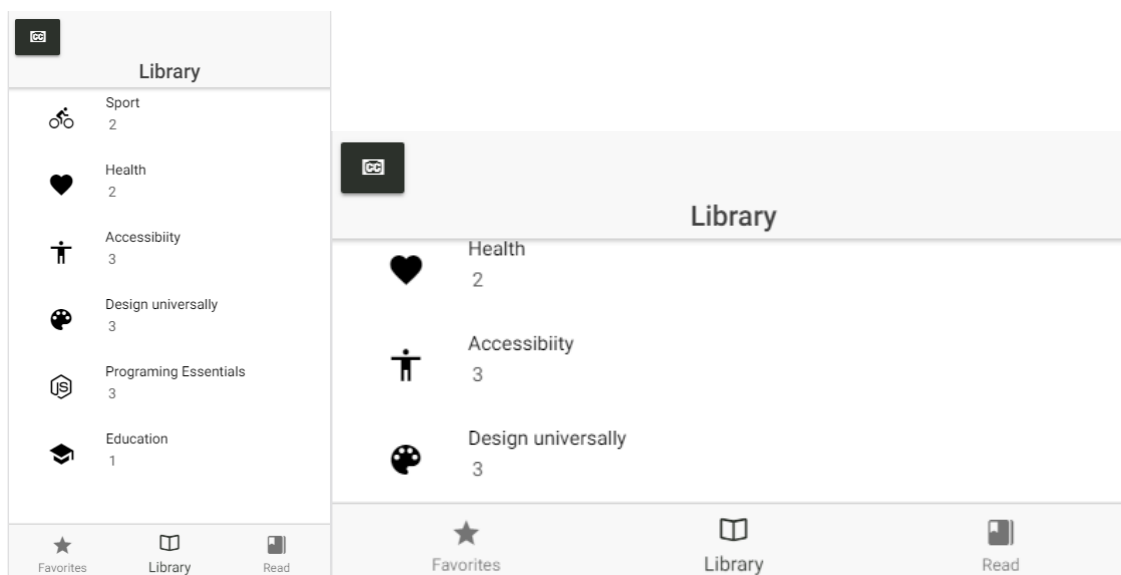
Some mobile applications automatically adjust the screen to a display orientation (Portrait and landscape). Mobile application's developers should try to support both orientations to make mobile content understandable for everyone. In addition, the flexibility in use comes when a product is responsive, and it works in different sizes and shapes of devices

Changes in orientation must be exposed to ensure detection by assistive technology such as screen readers application. For instance, NVDA ("Mobile Accessibility," n.d.). Moreover, if screen reader user is unaware that the orientation has changed, the user might perform incorrect navigation commands. Therefore, consistent layout, positioning important page, provide clear indication, provide custom instruction for custom touchscreen are the most important factors, makes the mobile content understandable for user.

Two pictures below shown that the book reader application is adjustable for to landscape and portrait positions.

Provide clear indication means feature in mobile interface should be distinguishable. For example, color offset, shape with different background color to distinguish the element from the page background, different text color. Another example is underlined text links, color for links.

Figure WCAG_4: Portrait and landscape illustration.



Flexibility in use which is the second principle of universal design standard is evident in the book reader application as it works in different scales screens and diverse range of platforms such as IPAD, IPAD Pro, IPhone6/7/8, IPhone X as well as all other portable devices.

4.4. Robust:

User can enter information to mobile device through a different way. For instance, through on-screen keyboard, Bluetooth keyboard, touch and speech. Reduce an amount of text entry needed by providing radio buttons, check boxes as well as menus. Therefore, this way provides easy method for data entry("Mobile Accessibility," n.d.).

In addition, the presence of virtual keyboard besides, device's own keyboard makes a device more robust for data entry. This can be set by the user or can be set to a specific keyboard. In addition, platform

characteristics such as zoom, larger font and caption have a profound effect on making content more accessible for disabled users.

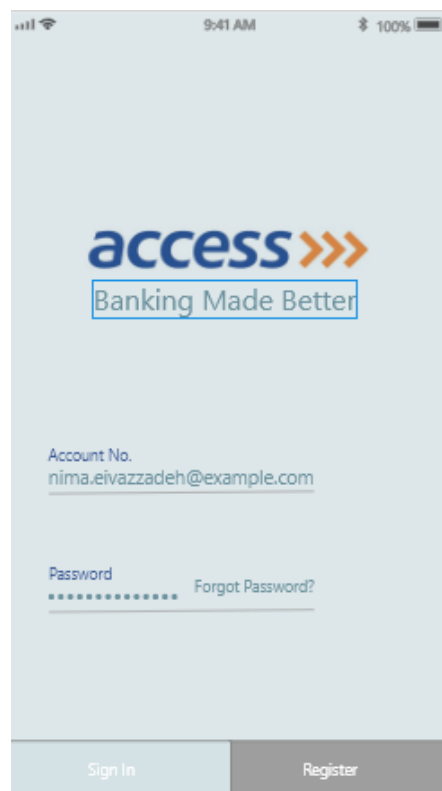
5. Banking prototype

The second application made for the project is a mobile bank system.

Banking system presents three interactive pages. First page is a login page. The application is used when people want to check their monthly basis transactions. For instance, how much money they paid for taxi trips within a month or how much money they paid for petrol and so on.

Picture below shows the first page of that application.

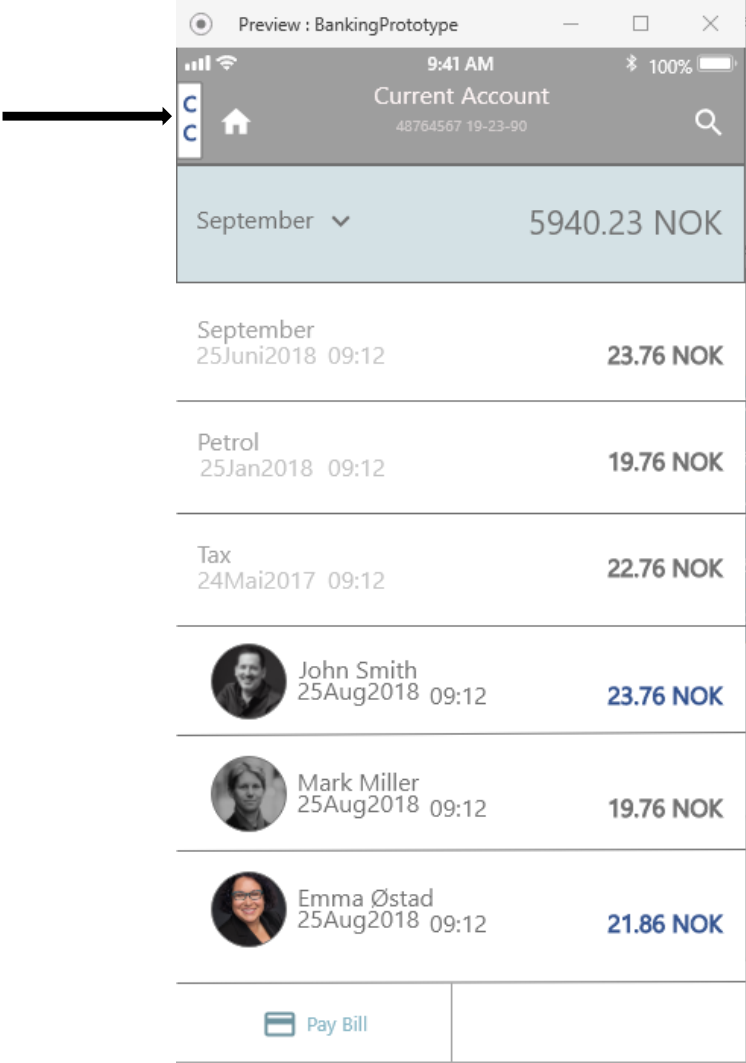
Figure 16 First Page of the user interface



The Contextual Cues feature in the application is shown as a little box located on the left corner side of the screen. Users can check their account balance, ask for a help from support team as well as chat with them to receive help from related authorities.

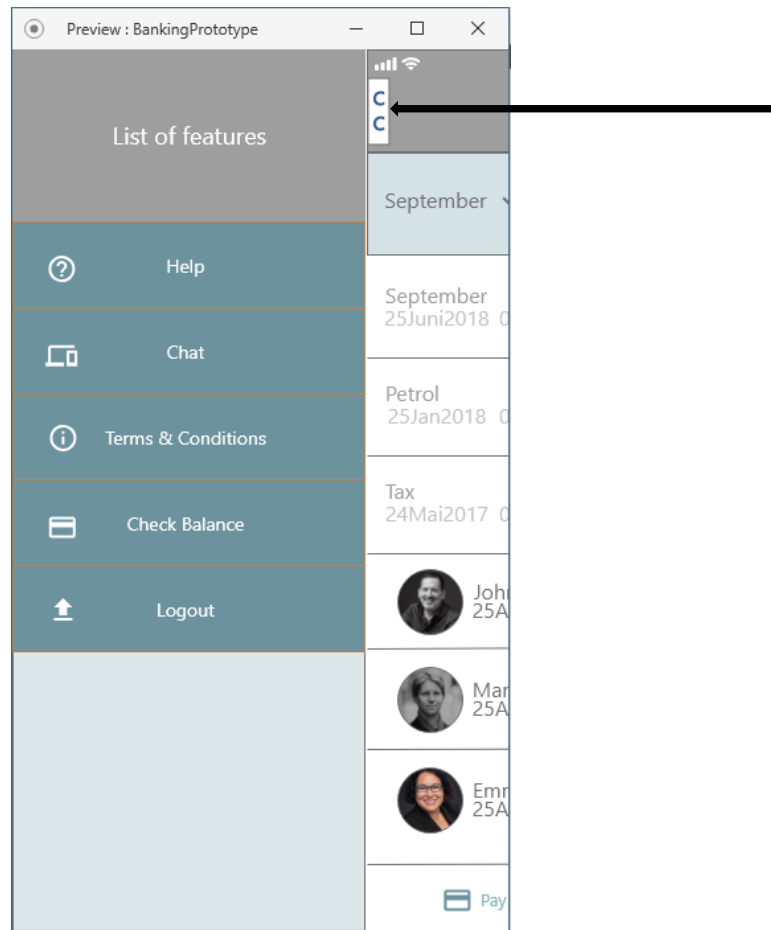
Picture below is the second page of the application. As it presents the contextual cues feature is available on this page to help people to access to the hidden feature of the application.

Figure 17: second page with the CC sign



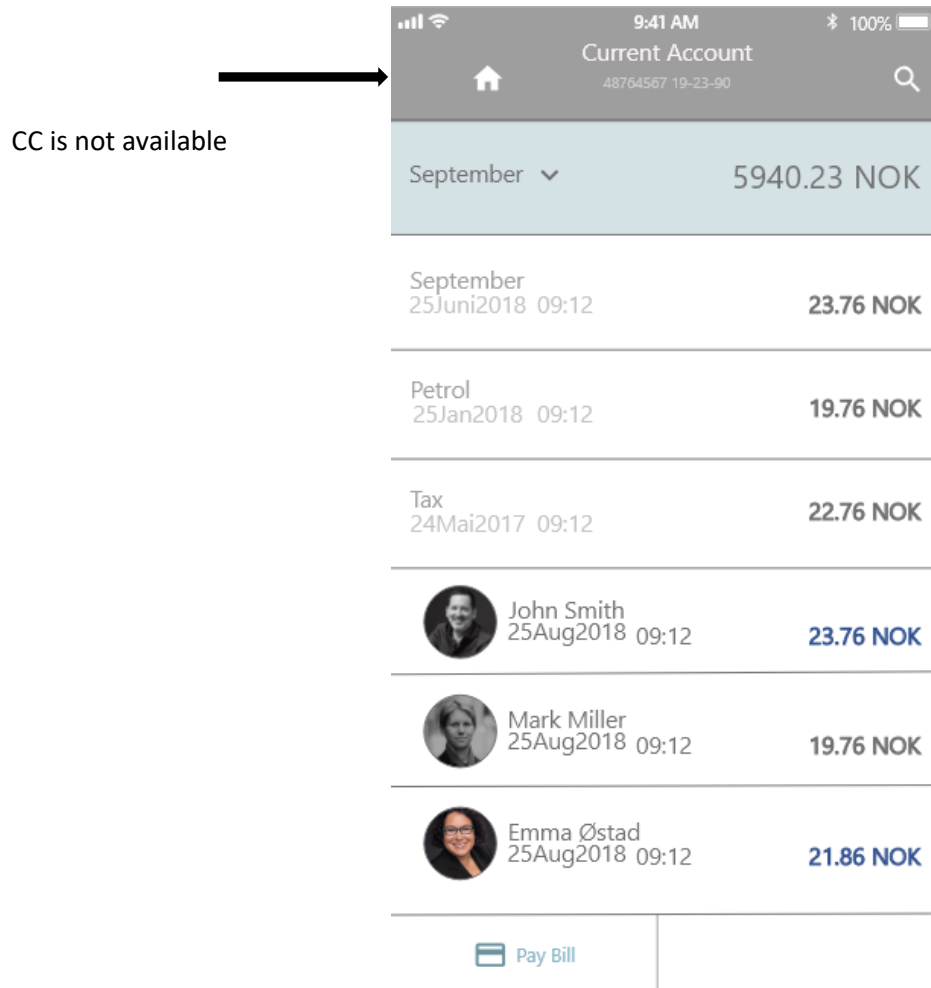
In order to access to the items located on the list users should push/click to the Contextual Cues button. Picture below illustrates that items on the list as well as the Contextual Cues button on the screen.

Figure 18: list of features in banking system



The below screen shot is the second version of the application presents the application without contextual cues sign. In other words, the CC' box is not available for users during the interaction so that users should swipe the page from left to the right side of the screen in order to get access to the list of features.

Figure 19: second version without CC sign



The below screen shot presents that the CC box is not available during an interaction for users so that user should arbitrarily swipe the screen from left side of the screen to the right. side.

Figure 20: List of features without CC box

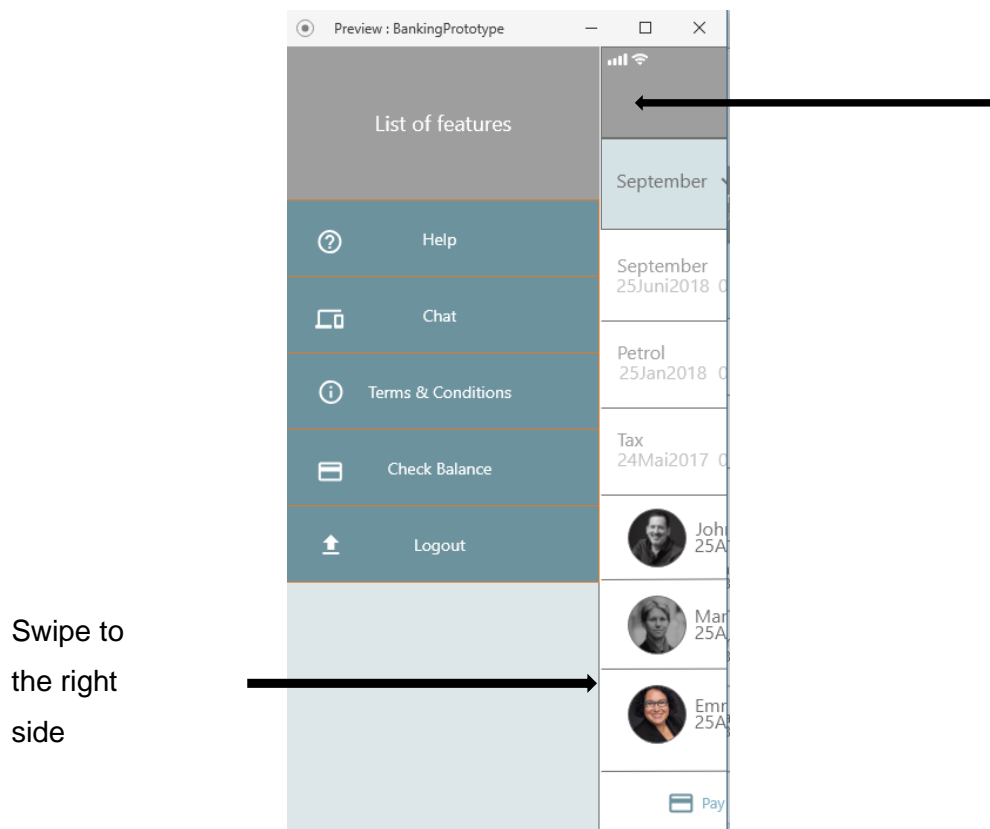


Figure twenty presents the list of hidden items on the left side of the mobile interface. These are available on the application but there is not any sign to inform users. Therefore, users should swipe the screen to the right side of the phone.

In the next chapter the author explains the methodology used for data collection for the project from participants based on the interview conducted as well as the survey for evaluating the Contextual Cues feature on mobile interface in terms of usability and user's satisfaction.

6. Methodology and data analysis

The methodology chapter indicates type of methodology used for the project. The project uses qualitative methodology.

With the growing of qualitative research methodology on human computer interaction and social computing it is natural that researchers may choose to conduct that research over telephone or computer network through social medias such as Facebook, Instagram and others.

There are three qualitative data collection such as phone, instance message and email(Dimond, Fiesler, DiSalvo, Pelc, & Bruckman, 2012).

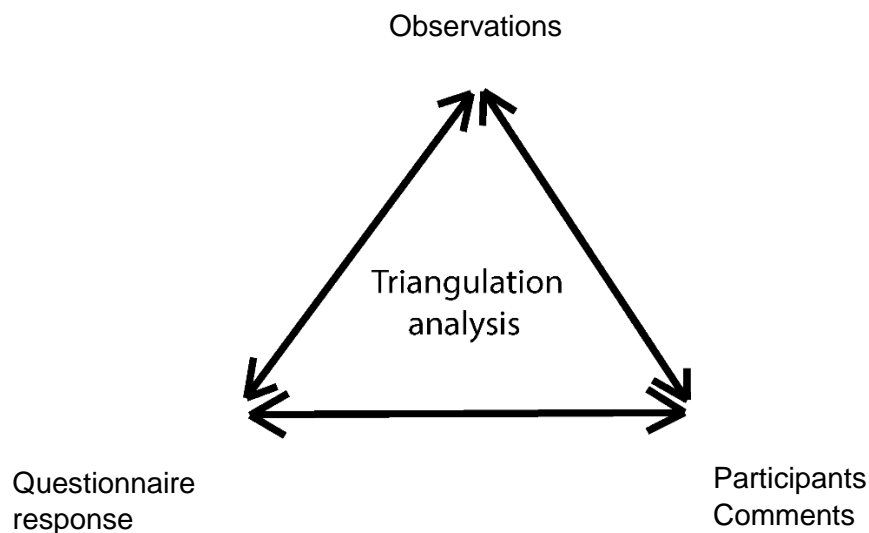
Qualitative interviewing is an invaluable tool for understanding human behavior (Dimond et al., 2012). In other words, it is rich and textual so that it provides in-depth information regarding what data collected on. It is exploratory research and it is used to understand of reasons, opinions and motivation(Dimond et al., 2012).

Qualitative metrics can give us immediate access to 'what' people do and with 'whom'. In addition, qualitative method can help us to understand 'why' (Dimond et al., 2012). Additionally, as researchers potentially turn attention to people's behavior online, an intriguing methodological question plays a significant role.

Qualitative interviewing is a technique that has its own roots in several disciplines such as anthropology, psychology and sociology (Dimond et al., 2012). It allows researcher to conduct in-depth analysis of user's behavior.

6.1. Triangulating the data from findings:

Carol reported that, Triangulating is a research technique, used in qualitative research studies to demonstrate the dependability of the findings by examining the data from multiple perspectives/views. P (260). Figure below illustrates Triangulation analysis.



Triangulation brings together different data sources to enrich the analysis of findings.

Carol reported, In the presented analysis the interviewer/tester look at the time-on-task results to see whether all participants completed it in five minutes or less. P (260). Then you look at the logs for each participant to see how they were doing the task, any questions or uncertainty they may have expressed. Do they successfully completed the task, and how responded to task questionnaire to rate their satisfaction with process?

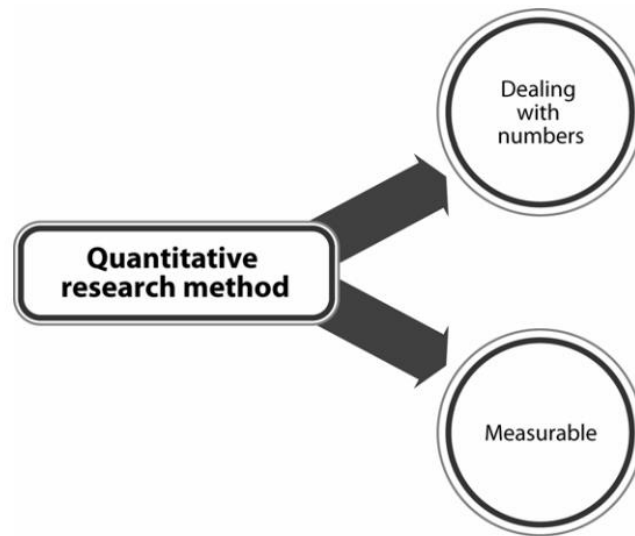
On the other hand, quantitative method relies on numbers and exact units. Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques (Labaree, n.d.).

It is used to answer questions on relationships within measurable variables with an intention to explain, predict and control a phenomenon (Leddy 1993).

John et al reports “Quantitative analysis uses numerical methods to ascertain the magnitude, amount, or size of something, the attributes, behavior, or opinions of the participants. For example, describing a population, quantitative analysis might conclude that the average person is 4 feet 10 inches tall, weighs 180 pounds, and is 35 years old. Moreover, qualitative analysis focusses on the nature of something and can be represented by theme, patterns as well as stories. For instance, in describing the same population, a qualitative analysis might conclude that the average person is tall, thin and middle-aged”. (p.271).

An entire quantitative study usually ends with confirmation or is confirmation of the hypothesis tested. Researchers using the quantitative method identify one or a few variables that they intend to use in their research work and proceed with data collection related to those variables.

Figure 21: Quantitative methodology



In Information and Communication Technology the quantitative methods usually deal with results computation and system analysis using a scientific approach.

7. Data Collection Methods

7.1. Observational data

Observation refers to record of human behavior in a natural situation and to analyze the records and deliver. In the presented research study in order to understand users' behavior the interview was conducted. The duration and the number of participants is presented on the duration section.

7.2. Interview

Interviews as a data collection method is obtained and has an ability to give in-depth insight to provide ideas towards the Contextual Cues feature in the user interface. The interview was conducted semi-structured to make a friendly and flexible conversation with participants. In semi-structured interview the initial questions specified.

Interviews are in fact extremely important in human-computer interaction research, serving both as one of the more invaluable and more challenging method (Dimond et al., 2012).

Phone method can produce the highest number of unique codes that were relevant to the topic of inquiry (Dimond et al., 2012).

Diverse category of communication media provides convenient alternatives. For instance, telephone, instant message and email (Dimond et al., 2012).

John et al reports “raw interview data is usually in the form of interviewer notes. The notes need to be written up and expanded as soon as possible after the interview has taken place so that interview’s memory is clear and fresh”. (p272)

Traditional interviewing is the most popular type of interviews which was conducted face-to-face many years in different industries. However, as the presence of online communities and social computing environment has increased our participants might be distributed around the globe where face-to-face interviews are often possible for practical reasons (Dimond et al., 2012).

As a result, questions were typically asked verbatim to the respondent. I, as an interviewer can modify existing questions in any way or may be devise completely new innovative questions to get more accurate results.

Semi-structured interviewing strategies rely heavily on the analyst being careful to success terminology about the work domain from potential users with minimal bias (Wood, 1997).

7.3. Interview data

There was a list of questions and topics which were covered within the order for the interview part. The most interviews conducted face-to-face with participants. Moreover, the author did a few interviews through social networks such as Facebook and email. In the verbatim interview, the author tried to use time and a place where satisfies participants to motivate them

to participate in the research study. Duration of the interview, time and location are presented on the duration section.

The goal of the interview was that to measure how much Contextual Cues feature is usable in mobile interface. For instance, users are satisfying with the presented feature or it makes them confusion during an interaction in mobile platform. Does it make interaction more understandable for users or not.

In order to motivate users to focus on the questions and to have an accurate feedback, I surprised them by an amount of money as well as gifts as a payment method in the end of the interview. Besides, there were a few challenges during an interview. For instance, a few of participants who had seniors (almost elderly) were not be ability to work with mobile devices because their hands were shaken during interaction with the book reader application.

As a result, they asked for a training event to get more familiar with the functionality of the application so that user testing for the mentioned participants were took more time compared with other younger users.

7.4. General procedure

In the face-to-face interview participants asked to fill out the consent form for the agreement. I asked them to get permission for writing their feedback down in a piece of a paper since the data obtained from the interview needed to be analyzed.

7.5. Participants

Participant were mostly involved young students and retired humans. As the author needed to have experimental data from diverse people, I have tried to include different age group people with different range of abilities in my interview event. Table 2 shows the participant's demographic information.

7.6. Interview guide

The interview form and the interview questions has been included in the appendix section of the document which is located at the end of the report.

7.7. Duration

The interviews were planned to last for approximately 15 to 25 minutes for each participant. The average duration of interview was around 21 minutes and 23 seconds. The most significant difference between the shortest and longest interview duration influenced by the participants skills for using the application and a bit range of stress which the aged people had during the interview. As a result of that interview I have experienced that user's ability to interact with mobile phones as well as their mood in the time of interview are significant factors and have profound effect on the result of the interview data. The face-to-face interview had ten participants which two of them were over 40 years old people with the low skill they had regarding interacting with mobile devices. The average number of interview's time related to them was beyond 25 minutes since they asked so many questions regarding the functionality of the book reader application during the interview.

Table 2: Demographic information of participants

| Number | Age | Gender | Occupation |
|--------|-----|--------|----------------|
| 1 | 18 | Female | Student |
| 2 | 26 | Male | Student |
| 3 | 32 | Male | a taxi driver |
| 4 | 46 | Female | A dentist |
| 5 | 37 | Male | A PhD student |
| 7 | 52 | Female | A chef |
| 8 | 37 | Male | A student |
| 9 | 25 | Male | A student |
| 10 | 40 | Female | A sales person |

7.8. Time of day

The face-to-face interview were conducted during weekends when participants had free time. In addition, a few of interviews were conducted during normal working days after working hours. From 18:00 to 19:00 in the evening.

7.9. Location

The location of the face-to-face interview was in the Oslo Metropolitan University premises as well as users' own place. As participants requested to have a safe and calm place so that they needed to have access to water closet. Therefore, interviews hold on the university premises and in participants place. Snacks and water were provided for them during the interview beside a promised gift which was given at the end of the interview.

8. Usability testing

The reason for usability testing is to be assure that the product meets usability essentials such as effectiveness, efficiency and satisfaction.

Barnum reports, Effectiveness and efficiency support the user's need to obtain a goal for using the product with accuracy and speed. (p.11). In addition, this means that the product supports the user in a way that is better than the current way through which the user works. This is a value-added part of usability.

Barnum reports, "Beyond effectiveness and efficiency, however, is the critical criterion of satisfaction. Although measures of effectiveness and efficiency are to some extent, determined by the user's perceptions of these qualities, there is no denying that the measure of satisfaction is derived wholly from the users' perception of satisfaction" p (12).

It critical to know who users are and what their goals are. Of Course, we need to know about users and their goals for all aspects of user-centered-design, but it is particularly significant in planning for usability testing. Therefore, we should recruit the right participants and give them the appropriate tasks.

8.1. Consent form

Before conducting user testing the potential participants should read and sign the consent form. The consent form should have two obligatory parts

(Lazar et al 2010). First, it must provide clear and understandable purpose of research for the participants (Lazar et al 2010).

In addition, it should be a form with clear, understandable and accessible text inside. The reason behind is that participants should be able to make right decision regarding their participation in research. The second part is an agreement between researcher and users. In other words, they should clearly be informed that their identification is not include into the research report.

The consent form has several sections so that they are as follows Lazar J. et al (2010):

Introduction, title and purpose of study, description of the procedure, risks of participation, benefit of participation, information about confidentiality of participation, participant's information, contact information of the researcher and any supplemental information for participants. Based on information presented above the consent form was provided. (see Appendix B).

8.2. User testing process

Participants asked to follow the given task step by step. Table below shows the list of tasks given to participants during user testing of book reader and mobile banking system.

Table 2: The list of tasks given to participant during user testing.

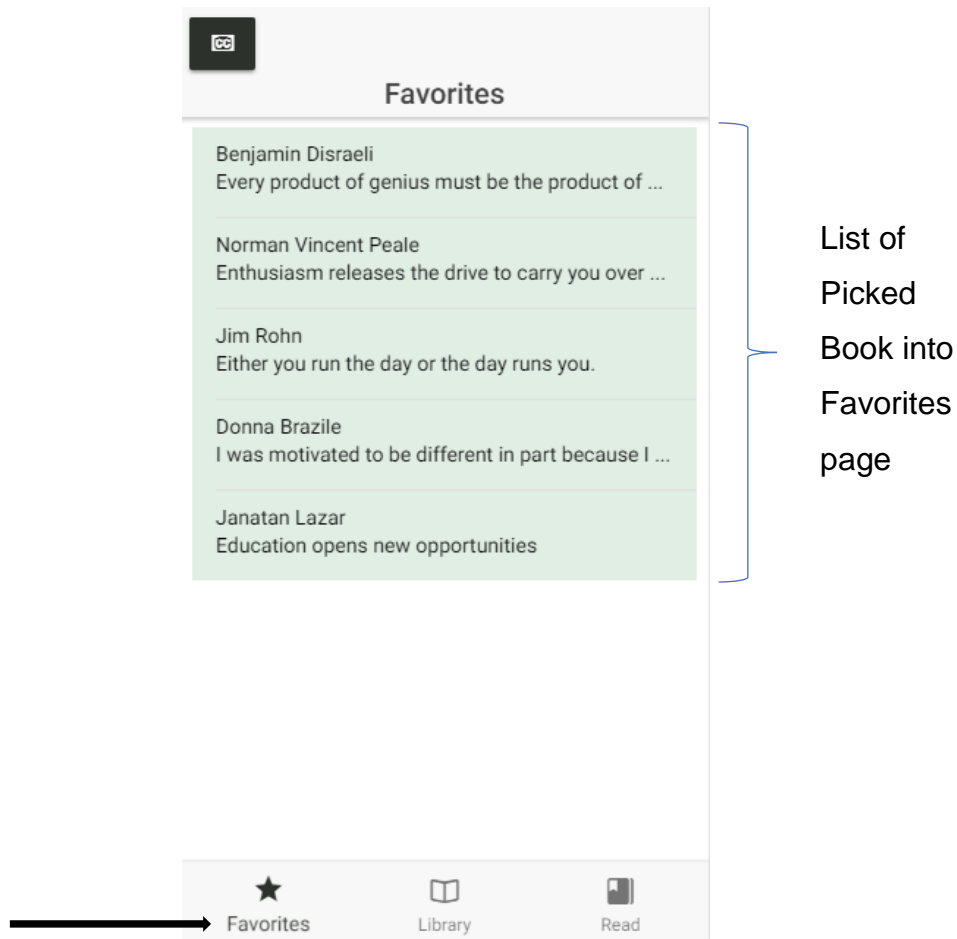
| Platform | Task |
|--|---|
| Book reader application without Contextual Cues feature | <ol style="list-style-type: none"> 1. Choose 4 books from different categories from the List. 2. In each category choose your book by clicking on favorite button. 3. Go to Favorite tab and review your chosen books. 4. Go to Favorite list pick one book. 5. Go to Favorite list pick one book and swipe the screen to left side. 6. Work with the hidden features such as trash and color palette. 7. Try to access to the hidden features of the application. |
| Book reader application with Contextual Cues feature | <ol style="list-style-type: none"> 1. Choose 4 books from different categories from the List. 2. in each category choose your book by clicking on favorite button. 3. Go to Favorite tab and review your chosen list. 4. Go to Favorite list pick one book. 5. Click on the CC button located on the left top corner of the screen. 6. Work with the hidden feature (list of features). 7. How do you evaluate the aesthetic of the design. |

| | |
|---|---|
| | 8. explain your feel regarding the Contextual cues feature on the user interface |
| Banking system without Contextual Cues feature | <ol style="list-style-type: none"> 1. Press on sign in button. 2. Work with the application. 3. Try to access to the list of features lists. |
| Banking system with Contextual Cues feature | <ol style="list-style-type: none"> 1.Press on sign in button. 2.Work with the application 3.Press to the CC button located on the top left corner on the screen. |

During the process of user testing users went through the given tasks for both prototypes. First, they asked to follow the given task for the book reader application.

For instance, they were asked to pick up books from different categories form the Library tab to fill in the Favorite list. Therefore, when the Favorite list filled out by list of books. Then, users can scroll up and down to the list to review the selected books.

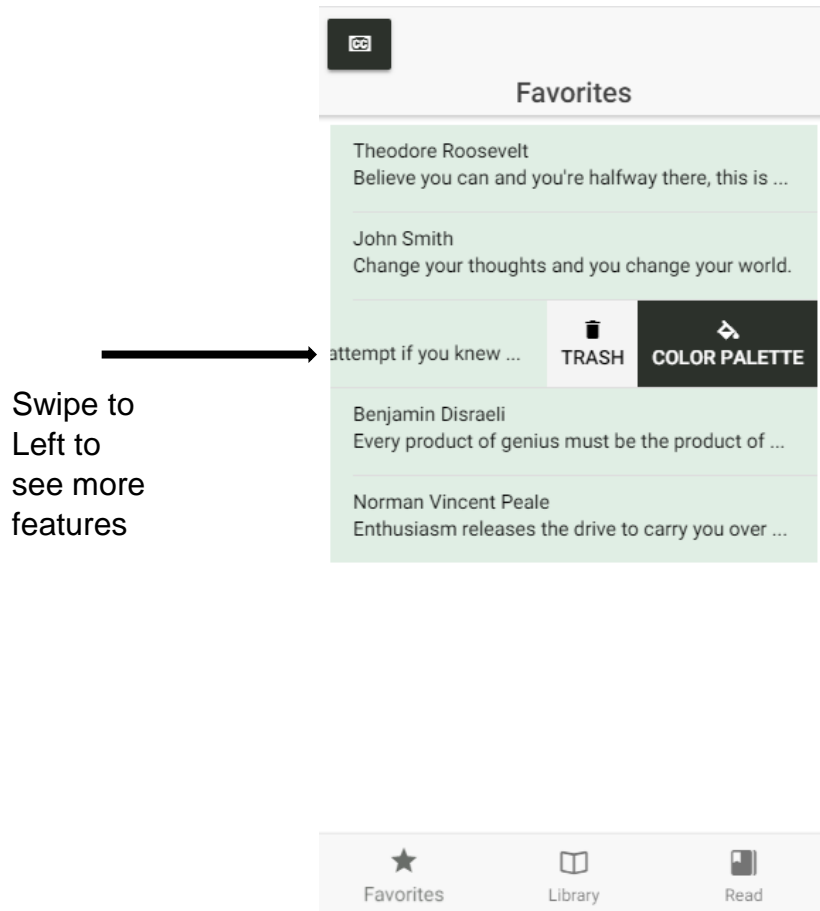
Figure 22: List of Book in Favorite List.



Moreover, in case they want to remove each book from the list, they are probably allowed to select each one, then, swipe the text to the left side the screen to remove a book from list by the 'TRASH' option which is hidden under each title of the book.

The picture below shows the mentioned problem.

Figure 23: Trash and color palette feature behind each book.



9. Analysis

User testing has been finished, there are logs, session, observer forms, participants questionnaires. All of them as a data collection are ready for analysis section. Therefore, making sense of all can be overwhelming.

Lazar, 2010 reports, there are two different approaches to analyzing data so that those are as follows: emergent coding as well as priori coding.

“emergent coding refers to the qualitative analyses conducted without any theory”. Or, model that might guide your analyses (Lazar et al 2010).

“A priori coding involves the use of an established theory or hypothesis to guide the selection of coding categories” (Lazar et al 2010).

Barnum reports, the process of analysis can be broken into three distinct steps so that those are based on the below questions. P (239).

1. What did I see?
2. What does it mean?
3. What should I do about it?

It is very important to pay attention to the questions in order. Because it is extremely tempting to jump from step one to step three without taking a time to understand what the findings mean.

In accordance with step one, gathering input from everyone, involving their positives, negatives and surprises should take it into account.

Everyone who observed the test has opinions about what worked and what did not. As a result, I as a tester can probably start a list of issues on the top of my head.

9.1. Top positive findings from the book reader application with the contextual cues feature

Color scheme on the mobile interface are easy to understand. As the application uses black, white and a light green color. All participants reflected that they don't have huge difficulties or understanding problem regarding color scheme of the application. There are a few issues so that those are mentioned on the negative findings section.

Buttons such as () are easy to use as their size and shape are big enough on mobile interfaces so that it does not require to make effort to touch many times on the buttons in order to function. In addition, each button has an informative text. Therefore, when a user clicks on that the status on the button changes to 'unfavorite' () so that users can easily understand that the book has picked from the list and shift it into the favorite list. This feature refers to the operable feature of the WCAG standard discussed above in the W3C section.

In addition to top positive findings participants surprised by (List of Hidden Features) which are achievable by the Contextual Cues sign/button locates on the top left corner of the screen. Features such as 'light', 'Calculator' and 'print' were very amazing for them. In addition, they reported that by the light feature they can easily access to the Phone's light when they are reading a book. Moreover, they presented that through the 'print' feature

they can print their desired text inside a book very quickly so that it makes simpler way for them to access in a section or a chapter of a book.

It is great to mention that the book reader application is responsive. This means the application works in diverse platforms without any problem in the user interface design. In other words, it works in big screens and small screens.(the second principle of universal design standard, flexibility in use) so that users can easily use it in every desired portable devices such as, iPhone iPad, iPad pro as well as on different kind of tablets, big screen mobile devices, small screen mobile devices in portrait and landscape scale.

9.2. Top negative findings from the book reader application without Contextual Cues

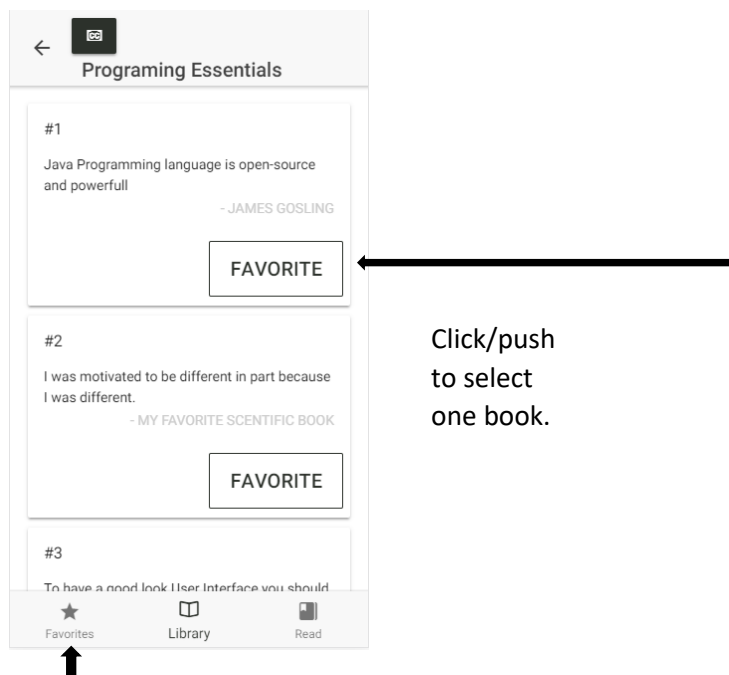
Access to two hidden features such as “color palette” and “Trash” located under each selected book in the Favorite list is negative point .It means they are not accessible (*Trash and color palette feature behind each book*). In other words, there are not any features shows as a sign or cues to report them that those are behind each selected book in the Favorite list. Therefore, they find those features accidentally when they swiped each selected book from the list (*Trash and color palette feature behind each book*).

Reading a book in mobile platform is a bit difficult and challenging since it is not possible to read texts in small screens in small font size for a long time. Presented, issues exist in portable devices specifically on mobile phones as well as very small devices or small gadgets. Moreover, the mentioned

issue is not applying for big screen portable devices such as tablets as they give bigger screen area for users.

Navigating from each tab to the list of favorites is a bit confusing. This means when user select a book from related category, they must push/click to the 'Favorite' tab (the star arrow key below shows that issue) icon to navigate to the 'Favorites' list.


Figure 24: Programming essential category



Should be pressed manually when a book selected by FAVORITE button (List of Book in Favorite List)


Tab's icon such as Favorite, Library and Read have small illustration (icon) relevant to each text in terms of design point of view. It would be great if those could be larger than they are. In addition, the author text has a low opacity so that it is difficult to read that text itself.

For example, (- MY FAVORITE SCIENTIFIC BOOK).

The CC text is not informative, and text is very small so that it is not possible to see the text. . In addition, size of text when they want to read the book in reading area is small and there is not a feature allow them to increase the size of the text.

9.3. Top positive findings from the banking system application with Contextual Cues

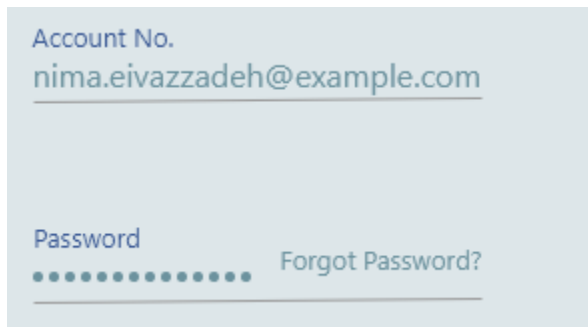
The Contextual Cues feature is necessarily useful in the application, since without it, users cannot access to the list of features of the application. Moreover, Color schemes used for the entire application are simple and understandable (the third principle of universal design standard, simple and intuitive use). This means everybody can benefit with the design of the product.

The home icon () on the top left corner of the screen demonstrates that user can reach to the first page of the application. Therefore, designing informative icon/button in the user interface would be very helpful for users as they can easily understand the functionality of the button.

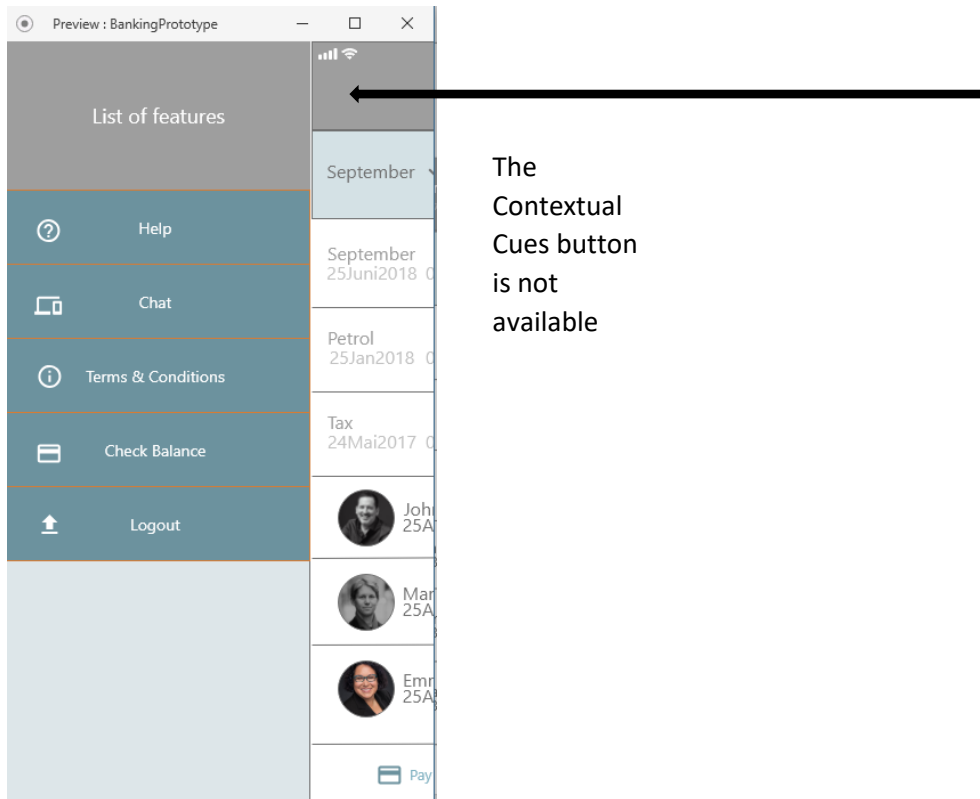
9.4. Top negative findings from the banking system application without Contextual Cues

Text in the login page are too small so that it is a bit challenging for users when they want to write username and password in the login section.

Figure banking system login page



There is not a sign to inform users that the application has a list of features a sign such as contextual cues. For instance, how it is possible to logout from the application as the logout button is in the list of features. How is it possible to access to the chat feature in case of need? !!



In addition, how it is possible to access to the ‘help’ feature on the application in case of needing help from the related authorities in the bank. Access to the ‘check balance’ feature which is in the list is not possible without the presence of the contextual cues.

The home button in the application navigates users to the login page. This feature is helpful, but it is not necessary, and it does not have informative text to inform user about the functionality of the button. It is just an icon.

Therefore, instead of home button it would be better to have a logout button with an informative text to inform user about the functionality of that button.

All the features mentioned by participants are available in the application as a list of features, but those are hidden (*list of features in banking system*) and they are not accessible, because there is not any link, button, sign or a cue to help them to navigate users to the presented list.

Moreover, they reflected that, the CC abbreviation is not informative. It is better to write the whole text rather that abbreviation as a text.

9.5. Validity

Validity is a significant concept in Human Computer Interaction as it measures the accuracy of the findings accomplished from the research study (Lazar et al, 2010).

There are three primary approaches to validity so that those are as follows:

9.5.1.Face validity

9.5.2.Criterion validity

9.5.3.Construct validity

In face validity which is the subjective validity criterion that usually requires a human research to understand the content of the data to assess whether on its 'face' it appears to be related to what the researcher intends to measure (Lazar et al, 2010).

As I needed to observe participants during user testing so that I thought about face validity to understand that what happens in users' face when they are working with applications. In other words, how their face acts during interaction with both prototypes and how they reflect what they feel.

Although face validity can serve as a helpful technique to detect suspicious data in the findings that need further investigation (Lazar et all, 2010).

9.6. Heuristic evaluation

Heuristic evaluation is an inspection method uses in computer software industry to help to identify usability issues in the user interface design("Heuristic evaluation," 2019).

In addition, heuristic can be used effectively to understand that which part of application have accessibility issue and provide useful insight into how to get a right solution (Paddison & Englefield, 2003).

Lauesen reported that heuristic evaluation and usability testing are two different techniques for finding usability issues. p (443).

This means in heuristic analysis evaluator looks at the user interface and identifies the problems. In contrast, with usability testing, participants doing a few tasks given to them. Therefore, problems found with usability testing is true problems through which at least one user find each problem, but problems found in heuristic evaluation are potential problems p (443).

The heuristic evaluation was conducted to identify the barriers in design of user interface with the goal of finding potential problems for those prototypes.

Nielsen (1994) reports, The heuristic evaluation conducted by the ten factors such as (“Heuristic evaluation,” 2019):

- 9.6.1.** Visibility of system status.
- 9.6.2.** Error prevention.
- 9.6.3.** User control and freedom.
- 9.6.4.** Consistency and standards.
- 9.6.5.** Error prevention.
- 9.6.6.** Recognition rather than recall.
- 9.6.7.** Flexibility and efficiency of use.
- 9.6.8.** Aesthetic and minimalist design.
- 9.6.9.** Help and documentation.

The book reader application as well as the banking system were evaluated based on a few factors presented above in terms of heuristic evaluation.

9.6.10. User control and freedom evaluation.

In this evaluation I tried to evaluate and understand how the book reader application gives freedom to users to find their goals. Does the logic of the application address them to do a specific task or user freely can use, understand and find their goals by working with the application?

9.6.11. Error prevention used to understand how many mistake participants produce and how it is possible to prevent errors generated by the users.

9.6.12. Aesthetic and minimalist design evaluation used to understand that how much design of prototypes satisfies participants during user testing.

9.6.13. Flexibility and efficiency of use was concerned during evaluation to understand that how much those applications are flexible to use for target audience.

Result of the evaluation is in the result section.

10. Results

This section represents findings from data collection method as well as analysis.

Findings from analysis shows that the Contextual Cues feature in mobile interface is sometimes helpful and sometimes not for users as a guide. In addition, my own research and experience from user testing reveals that there is a difference between what people 'say' and what they 'feel'.

The presented problem is obvious for the author as a researcher based on the experience he got from interviews and user testing.

As an example, participants claimed that a few features or items in mobile book reader and banking system applications are not understandable during user testing, but I as a tester observed them during user testing so that they showed that they can easily find what they are looking for or they can track given task without any important problem. For instance, when they asked to find book reader's hidden features such as trash and color palette, those participants who have not had computer-related experience claimed that it is a challenging task. In contrast, those who were computer-related skill reflected that finding hidden features are easy as they had similar experience from another application same as book reader and mobile bank system. Therefore, in this situation I realize that computer-related skills and experience could have positive point for the presented issue, and it can boost up time during user testing event.

Barriers or obstacles they encountered was the lack of experience they had when they wanted to work with applications. This means, at the first time

they were not aware that how to use the application but after while they completely understood and followed the instructions. Therefore, I realize that teaching users to how to use a software would have a profound effect on what they reflect as a feedback on that software.

10.1 Finding from heuristic evaluation

10.1.1 user control and freedom evaluation

The result related to user control of the application reveals that the book reader application does not have potential or specific feature/s related to control issue which make inconveniences for them during interaction. This evaluation is valid for application with the contextual cues feature since users have access to the list of features.

In addition to freedom evaluation user testing revealed that the book reader application does not give freedom without contextual cues feature, since they cannot access to the other features of the app on the list.

There are a few issues related to the typeface of the mobile interface in book reader application which participants were not satisfied. Typeface problems. For example, contrast ratio related to author's name for each category is unclear so that participants reported that those are problematic. Also, the size of text on both prototypes are a bit small.

10.1.2 result related to error preventing

During user testing participant made a few mistakes regarding a few tasks given to them. For instance, they could not understand the task such as 'Go to Favorite list pick one book and swipe the screen to left side.'

Therefore, that they asked many times to understand that what the task is

about. The presented issue happened for participants who had not computer-related experience but for those who had that experience there was not a huge problem. For instance, youngsters and students, as a result, I understand that task description is very important factor for users that should be take it into account.

In the banking system prototype **without** contextual cues feature there is a task which presents 'Try to access to the list of features' was a bit unclear for them as they presented that 'How' it is possible without the Contextual Cues feature.!

10.1.3 Aesthetic and minimalist design

This section presents that how much user interface of those products were satisfied users. In other word, how beautiful design is in terms of universal design and aesthetic point of view. Participants showed that they have not had any inconsistencies related to the design of user interface for both book reader and the banking system applications. As the author tried to design prototypes based on universal design standards which benefits people with diverse range of abilities. For instance, the size and shape of buttons and the color used in entire application.

Among ten participants one of them claimed that the design of banking system application is a bit confusing. He specified that the design of main page in banking system has so many texts. Therefore, he suggested that it would be better to have illustrations instead of text as illustration is easier to understand rather than text.

Therefore, he personally reported that the application does not have an enough contrast so that he should try to understand text by trying read text in banking system prototype.

Aesthetic in book reader application were satisfied by most of participants, but they claimed that icons related to each category are too small so that low vision users cannot benefit, and it makes them effort to understand icons with related text.

10.1.4 Flexibility and efficiency of use

As flexibility in use is a second principle of universal design so that the author tried to think about it and implement it into those prototypes to make flexible prototypes. For instance, the book reader application shows flexibility in use as it responsive and it works in diverse range of platforms such as PDAs, IPAD and IPAD pro, in Samsung galaxy note series as well as other third-party devices. As a result, it gives opportunities to users to use the application in every desired platform.

10.1.5 result of effectiveness

The book reader application works in the way that was intended based on what we want to demonstrate in the application. In other words, designing and implementing of contextual cues feature was successful for the project as I got positive feedback from user testing of this project. Although there was a bit misunderstanding existing for specific users (people who were not computer-related experience), but the overall result illustrates that the contextual cues feature is a successful idea.

10.1.6 results from social network participants

As I did user testing through social networks such as Facebook this section represents the result of those findings. A few of participants presented that the book reader application is very simple so that it does not have modern user interface. In other word, the design of the user interface had not satisfied them since they claimed that the color scheme and typeface is a bit weak. In addition, their feedback regarding the contextual cues feature was positive. They specified the availability of the feature in entire application. This means the idea of availability of the Contextual Cues button can help them easily access to other features of the application which they are not aware about them.

11. Discussion

In the following section, research presents discussion regarding the theoretical and practical aspects of the study. In other words, it represents researchers' understanding, difficulties, findings, thoughts on how research conducted. In addition, problems encountered during development of the prototypes to demonstrate clearly what the goal of the project is.

As there is not previous research study in contextual cues feature on mobile interface with the form I have accomplished. Therefore, I had challenging time during research to find relevant research study in order to link them into to my own project from academic databases such as ACM Digital Library, IEEE Xplore and other resources. In the beginning of the document I have reported and touched upon a feature presented by Samsung in its galaxy S8 product as an 'Edge panel' feature. Therefore, I found that the given example would be a right example regarding what the contextual cues goal is in mobile interface. During research study I tried to design and develop a product same as the Edge panel since I believe that Contextual Cues feature is a form of feature which Samsung has been presented on their Galaxy S series.

When the study comes to present the development of the prototype (the book reader) it is significant to mention that in the phase two of the project I had a technical issue to finish the development of the application .The problem was on the chosen framework in Ionic library which I decided to implement for the book reader application . This means the chosen framework was deprecated by the owner of the product and it was in

progress to generate new one., but fortunately I have solved the mentioned issue in the phase three of the project and completed the application based on what I aimed in phase one. As a result , I can conclude that lack of relevant research study was the weakness of my research study and I believe this research is a good start for future work

In the literature review chapter, there are a few visual illustrations shows the best practices of user interface design. These screen shots and visual illustrations picked from Google material design as I believe those suggestions are best practices to have a universal design production in terms of design point of view. I obtained the mentioned understanding from my experience in designing and developing user interface products for diverse businesses in the industry. Therefore, I found that it would be great to use those into my research study as I tested those in diverse project with real target users.

11.1 suggestions for future work

As I mentioned previously there are not many relevant researches done in the field of my study. Therefore, the field of study introduced by the report has more room for additional research and finding.

With regards to accessibility and people with specific conditions it is evident that the contextual cues feature could be useful for users who are suffer from Alzheimer or have problem remembering facts. As these people have issues remembering names, figures or may be access to hidden features in

applications so that by the presence of contextual cues as a guide they can easily access to the application's hidden features which they do not aware.

Alzheimer's disease is cognitive impairment and it is in the beginning of dementia so that patients have effect of daily activity and episodic memory loss (Triponywasin, Yamsa-ard, & Wongsawat, 2013).

12. Conclusion

This section answers to the projects' research question. In addition, suggestion regarding design and developing of contextual cues feature in mobile interface.

Do contextual cues feature in mobile interface have a positive effect on accessibility on mobile platform and makes interaction simpler, usable, understandable and robust?

Answer to my research question is positive.

Based on user testing and data analysis done for the project, result of the study research has been accomplished. Thus, through this research it is evident that the presented feature as a Contextual Cues can boost up the interaction speed between humans and mobile phones. In addition, through the presented feature users can easily access to all features for an application which they are either hidden or not on a mobile application.

In addition to finding through this research the size and shape as well as the color scheme of buttons in the presented applications can help people with specific conditions to understand content of mobile interface more clearly. People such as visually impaired and color blind can benefit more with the presented strategy on design as they cannot distinguished the differences between colors.

12.1 Propositions for future research

As the presented research study is completely new so that so many rooms would be available for the further work of this field of study. Research on

accessibility to hidden features (the contextual cues) which covers universal design standard on mobile interface is a new chapter in universal design of information and communication of ICT products. Moreover,

The result of literature survey presented that research in the form of contextual cues has not been done by many other user interface researchers and interaction designers. This means, the author tried to find relevant research paper and understanding in that area in order to demonstrate that what are the best practice design standards on mobile interface as well as how it is possible to make a design work simple and understandable which benefits everyone.

I, as a researcher in this field of study suggest to other researchers or designers who are designing mobile interface to think on simplicity and accessibility of all features of a software product.

It is quite evident that technology has a profound effect on people's lives in the recent decade. In other words, people have a challenging moment to learn how to use new emerged applications either on their mobile phone or on their own personal computer. Therefore, producing usable, understandable as well as accessible products can be positive influence on their challenging and makes life simpler for them in this aspect of the life. The contextual cues idea on mobile interface design is not away from this journey. This means, it tries to invent or produce a new feature which make live very simple for target users who live around the globe.

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Appendix A: Interview Guide

General information:

1. What is your name?
2. How old are you?
3. What kind of job you are interested in or did? (this question excluded for retire participants).
4. Do you have a good-tempered or bad-tempered personality? (I asked this to examine the tolerance of error)

Proficiency questions about working with portable devices and contextual cues feature.

1. What features in mobile interface make interaction more understandable and easier?
2. What have you experienced when you used Contextual Cues feature during your interaction with the device?
3. Does Contextual Cues feature make interaction easier during that interaction or not?
4. What barriers have you had/experienced during an interaction without Contextual Cues feature?
5. What kind of portable devices are you preferred to work with? For example, Tablet, Smartphones, PDA, etc.
6. How many years are you using mobile phone?

7. What do you do with your mobile phone? For example, are you only answering phone calls or doing something else? For instance, reading books, seeking addresses or purchasing on the internet?
8. What factors make you frustrate, fatigue and angry when you are interacting with your mobile phone for a long time?

Appendix B: Consent Form

**The current research is part of the Mater thesis research in universal
Design of ICT**

**Department of computer science, Faculty of technology, Art and
Design**

Oslo Metropolitan University

The name and information of the investigator:

investigator: Nima Eivazzadeh Kaljahi

Phone: +4745918554

Email: S320801@OsloMet.no

Introduction

You are being asked to be in a research study of master thesis with the presented subject.

We ask that you read this form and ask any questions that you may have before agreeing to be in the study.

Purpose of the study: The goal of this research study is to define that how contextual cues feature in mobile user interface affects users.

Procedure: participants in this study requires one meeting lasting approximately one hour. In the meeting we ask you to answer a few questions such as:

1. A few general questions about your skills and experience using mobile devices.
2. Doing some tasks or working with the sample application designed for the research study for observation purpose.
3. Questions regarding your experience obtained with Contextual Cues feature in the user interface.
4. The possibility of taking notes as feedback during an interview.

Risk/Discomfort of being in this study: there are not any known health risk involved in participating in this research study. If you feel any fatigue or discomfort during the process, you are free to take a break of leave permanently.

Benefits of being in this study: Your feedback and participation might contribute to demonstrates an efficient idea in Contextual Cues feature which may available during an interaction in mobile platforms so that boost the usability section of interaction.

Right to Refuse or Withdraw

The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time without affecting your relationship with the investigator of this study. Your decision will not result in any loss or benefits to which you are otherwise entitled. You have the

right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

Right to Ask Questions and Report Concerns

You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. If you have any further questions about the study, at any time feel free to contact me, Nima Eivazzadeh Kaljahi at S320801@OsloMet.no or by telephone at +4745918554. If you like, a summary of the results of the study will be sent to you. If you have any other concerns about your rights as a research participant that have not been answered by the investigator, you may contact Nima Eivazzadeh Kaljahi.

If you have any problems or concerns that occur as a result of your participation, you can report them to the Nima Eivazzadeh Kaljahi at the number above.

Cost and Compensation: participants in this study will involve no cost to you. You will be paid for your participation 100 NOK for each one.

Consent

Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigator.

I have read and understood the information of this form.

Subject's Name (print): -----

Subject's signature: ----- Date: -----

Investigators signature: ----- Date: -----

Appendix C: Book reader application code structure.

As report earlier mentioned the book reader application has been developed by Ionic framework, it is great to present that this technology is one of the most popular JavaScript's frameworks among mobile application developers as well as designers.

JavaScript has become the most widely used language for client side web and mobile programming(Gardner, Maffeis, & Smith, 2012). In addition, JavaScript has become an international standard called ECMAScript(Gardner et al., 2012).

JavaScript was initially created for small web-programming tasks, which benefited from the flexibility of the language and tight browser integration(Gardner et al., 2012).

Ionic is complete open-source SDK for hybrid mobile application development announced by Max Lynch, Ben Sperry and Adam Bradley in 2013("Ionic (mobile app framework)," 2019).

The original version was released in 2013 and built on top of AngularJS and Apache Cordova ("Ionic (mobile app framework)," 2019).

This section presents the technical part of the project briefly in detail.

Before start writing code by Ionic framework, the NodeJS package must be downloaded and install into a computer machine. Link below is the address to reach to the NodeJS package.

<https://nodejs.org/en/>.

In addition, a prerequisite tool for writing code by Ionic framework is a code editor software. This project uses VS Code editor which is an open-source editor announced by the Microsoft.

During development of the application the author had hard times with the Ionic technology in the middle of development. The author understood that the version used for developing had not been supported by technology owner. But, after a lot of effort, research and investigation the author finally found a solution and finished the development process.

As I aimed to show the Contextual Cues feature as a tiny box in the right or left corner of the mobile interface, the right class component and class library of the Ionic framework were not existing at the time of development. The presented issue happened approximately in the phase two of the project.

Figure below shows the structure of the application in a VS Code editor.



As it presents the project has SRC folder which is the core folder of the application so that assets, data, pages, services and themes are the sub

folders of the SRC folder. Each part of the application divided into different folders.

Figure below represents a JSON array involves all hard-coded book inside of the heart of the application.

```
export default [
  {
    category: 'Scientific',
    quotes: [
      {
        id: '1',
        person: 'Theodore Roosevelt',
        text: 'Believe you can and you\'re halfway there, this is a text which belongs to Roosevelt'
      },
      {
        id: '2',
        person: 'John Smith',
        text: 'Change your thoughts and you change your world.'
      },
      {
        id: '3',
        person: 'Emma Sanderson',
        text: 'What great thing would you attempt if you knew you could not fail?'
      }
    ],
    icon: 'flask'
  },
  {
    category: 'Sport',
    quotes: [
      {
        id: '4',
        person: 'John Wooden',
        text: 'Ability may get you to the top, but it takes character to keep you there.'
      },
      {
        id: '5',
        person: 'Robert Frost',
        text: 'Education is the ability to listen to almost anything without losing your temper.'
      }
    ]
  }
],
```


Figure below shows tab page code structure

```
import {Component} from '@angular/core';
import { FavoritesPage } from '../favorites/favorites';
import { LibraryPage } from '../library/library';
import { QuotePage } from '../quote/quote';
import { SettingsPage } from '../settings/settings';

@Component({
  selector: 'page-tabs',
  template: `
    <ion-tabs selectedIndex="1">
      <ion-tab [root]="favoritesPage" tabTitle="Favorites" tabIcon="star" ></ion-tab>
      <ion-tab [root]="libraryPage" tabTitle="Library" tabIcon="book"></ion-tab>
      <ion-tab [root]="quotePage" tabTitle="Read" tabIcon="bookmarks"></ion-tab>
    </ion-tabs>
  `
})
export class TabsPage {
  favoritesPage = FavoritesPage;
  libraryPage = LibraryPage;
  quotePage = QuotePage;
  settingPage = SettingsPage;
}
```

Figure below shows reading_page_typescript code structure

```
import { Component, ElementRef, ViewChild } from '@angular/core';
import { IonicPage, ViewController, NavParams, PopoverController, MenuController } from 'ionic-angular';
import { PopoverPage } from '../popover/popover';
import { LibraryPage } from '../library/library';
@IonicPage()
@Component({
  selector: 'page-quote',
  templateUrl: 'quote.html',
})
export class QuotePage {
  person: string;
  text: string;
  background: string;
  libraryPage = LibraryPage;

  constructor(private viewControll: ViewController,
              private namParams: NavParams,
              private popoverCtrl: PopoverController,
              private menuCtrl: MenuController,
              ){}

  ionViewDidLoad(){
    this.person = this.namParams.get('person');
    this.text = this.namParams.get('text');
  }

  onClose(remove = false){
    this.viewControll.dismiss(remove);
  }

  presentPopover(MyEvent) {
    const popover = this.popoverCtrl.create(PopoverPage)
    popover.present({
      ev: MyEvent
    });
  }

  onOpenMenu(){
    this.menuCtrl.open();
  }
}
```

Figure below shows reading page html code structure

```
<ion-header>
  <button ion-button (click)="onOpenMenu()">
    <ion-icon name="closed-captioning"></ion-icon>
  </button>
  <ion-title text-center>Read</ion-title>
</ion-header>

<ion-navbar>

  <ion-title text-center>{{person}}</ion-title>
</ion-navbar>

<ion-buttons slot="secondary">

</ion-buttons>
</ion-header>

<ion-content padding text-center >
  <ion-card>
    <ion-card-header>
      <h3> Reading page</h3>
    </ion-card-header>
    <ion-card-content class="master" >
      {{text}}
    </ion-card-content>
  </ion-card>

  <button ion-button
  outline
  round
  large
  color="secondary">
  Close
  </button>

</ion-content>
```

Figure below shows library page typescript code structure

```
import { Component, OnInit } from '@angular/core';
import { IonicPage, MenuController } from 'ionic-angular';
import { Quote } from '../../data/quote.interface';
import quotes from '../../data/quotes';
import { QuotesPage } from '../quotes/quotes';

@IonicPage()
@Component({
  selector: 'page-library',
  templateUrl: 'library.html',
})
export class LibraryPage implements OnInit {

  constructor (
    private menuCtrl: MenuController,
  ){}

  quoteCollection: {category: string, quotes:Quote[], icon: string}[];
  quotesGroup = QuotesPage;

  ngOnInit() {
    this.quoteCollection = quotes;
  }
  onOpenMenu() {
    this.menuCtrl.open();
  }
}
```

Figure below shows library page html code structure

```
<ion-header>
  <ion-navbar>
    <button ion-button (click)="onOpenMenu()">
      <ion-icon name="closed-captioning"></ion-icon>
    </button>
    <ion-title>{{quoteGroup.category}}</ion-title>
  </ion-navbar>
</ion-header>

<ion-content padding>
  <ion-card
    *ngFor="let quote of quoteGroup.quotes; let i = index">
    <ion-card-header>
      #{{ i + 1 }}
    </ion-card-header>
    <ion-card-content>
      <p>{{quote.text}}</p>
      <p class="author">{{quote.person}}</p>
    </ion-card-content>
    <ion-row>
      <ion-col text-right>
        <button ion-button
          outline large
          (click)="onAddToFavorites(quote)"
          *ngIf="!isFavorite(quote)"
        >Favorite</button>
        <button ion-button
          color="secondary"
          outline large
          (click)="onRemoveFromFavorites(quote)"
          *ngIf="isFavorite(quote)"
        >Unfavorite</button>
      </ion-col>
    </ion-row>
  </ion-card>
</ion-content>
```

Figure below shows favorite typescript code structure

```
import { Component } from '@angular/core';
import { IonicPage, ModalController, MenuController } from 'ionic-angular';
import { Quote } from '../data/quote.interface';
import { QuotesService } from '../service/quotes';
import { QuotePage } from '../quote/quote';

@IonicPage()
@Component({
  selector: 'page-favorites',
  templateUrl: 'favorites.html',
})
export class FavoritesPage {
  quotes: Quote[];

  constructor(private quoteService: QuotesService,
              private modalCtrl: ModalController,
              private menuCtrl: MenuController
              ) {}

  ionViewWillEnter(){
    this.quotes = this.quoteService.getFavoriteQuotes();
  }

  onViewQuote(q: Quote){
    const modal = this.modalCtrl.create(QuotePage, q);
    modal.present();
    modal.onDidDismiss((remove: boolean) => {
      if(remove){
        this.onRemoveFromFavorites(q);
      }
    });
  }

  onRemoveFromFavorites(q: Quote) {
    this.quoteService.removeQuotesFromFavorites(q);
    const position = this.quotes.findIndex((quoteEl: Quote) => {
      return quoteEl.id == q.id;
    });
    this.quotes.splice(position, 1);
  }

  onOpenMenu(){
    this.menuCtrl.open();
  }
}
```

Figure below shows favorite page html code structure

```
<ion-header>
  <ion-navbar>
    <button ion-button (click)="onOpenMenu()">
      <ion-icon name="closed-captioning"></ion-icon>
    </button>
    <ion-title text-center>Favorites</ion-title>
  </ion-navbar>
</ion-header>

<ion-content padding>
  <ion-list>
    <ion-item-sliding
      *ngFor="let q of quotes">
      <ion-item
        color="quoteBackground"
        (click)="onViewQuote(q)">
        <h3>{{q.person}}</h3>
        <p>{{q.text}}</p>
      </ion-item>
      <ion-item-options>
        <button ion-button
          (click)="onRemoveFromFavorites(quotes)"
          color="light"
        >
          <ion-icon name="trash"></ion-icon>
          trash
        </button>
        <button ion-button
          color="primary">
          <ion-icon name="color-fill" outline></ion-icon>
          color palette
        </button>
        <!-- <button ion-button
          color="secondary">
          <ion-icon name="call"></ion-icon>
          Call
        </button> -->
      </ion-item-options>
    </ion-item-sliding>
  </ion-list>
</ion-content>
```

Appendix D: Users direct feedback from prototypes

In the book reader application participants presented that the swipe feature is useful since they can adjust the background color of the page when their eyes becomes tired with the current color of the screen. Mostly aged participants showed positive reaction regarding the color palette feature. Moreover, they reflected that the 'trash' feature is helpful since they can remove items from the list if they want to remove books from Favorite list.

Participants feedback regarding the 'FAVORITE' buttons for the book reader application was positive. Two aged participants reported that the large size of the buttons is useful, because it fits their finger. So, for them it doesn't require to push on the buttons many times in order to a button function. They mentioned that they have problems with their own phone's button as they are very small size on the mobile screen.

The younger participants mentioned that the idea of the Contextual Cues is very interesting and helpful. For instance, they presented that instead of using color palette and trash features in the book reader, other features such as searching tool, or a bookmark feature would be a very efficient feature because they can search and find any specific paragraph inside a book. Therefore, by a bookmark feature they can make a note leave so that it would be easier for them to find the place of leave.

The summary of participant's feedback regarding the eight proficiency interview questions are as follows:

They reflected that they usually use mobile phones rather than tablets, PDA's and other portable devices, the below statement is their direct answer in friendly language.

“Mobile applications are diverse. In everyday life we are challenging with different kinds of mobile applications. In some cases, we must learn to use them. For instance, mobile bank applications are used with us almost every day, we transfer money to our kids, we spend money when we want to buy something etc. Therefore, it is inevitable that we cannot avoid them in our day to day life. So, it is very important for us to have applications easy to use, easy to learn and easy to understand.

Applications which has so many features inside are very confusing, frustrating and time consuming. We must try and learn required functionality, sometimes we cannot understand applications' functionality. So, we leave them behind, there is not good instructions for applications presents that functionality by visual illustration rather than lines of text. We must work with an application arbitrarily to get experience and learn before reviewing any instructions. For instance, in most applications there is a hamburger menu when you we click on it a list of features appears and each item has its own functionality. As an example, privacy and policy feature, profile and personal account, setting has a lot of different options. In addition, these features are frequently changing when the applications give new updates from their own server. Sometimes it doesn't make sense for us how they work and what should we do.”

Appendix E: Material used for user testing

During the research process following materials were used:

Interview questionnaire as well as pen and paper for writing users' feedback. All those data were deleted after analysis as the author promised those are will be deleted after analysis has been done to participants.

It is important to mentioned that the book reader application was tested through two ways. First on the browser "Google Chrome". Second on the real mobile device. Therefore, the observation notes during the interview was taken.