An Dang

VISUALIZATION OF A MOBILE INTERACTIVE ROUTE MAP

Creating a mobile app's User Interface

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Abstract

An interactive navigation map is not only a tool for traveling but also a contribution to the whole experience the user has when using an application. Its visualization and functions have to follow not only the mapping standards but also the product's general guidelines and style. The thesis attempt to analyze cognitive psychology related to wayfinding and spatial environment awareness. It leads to an understanding of how people follow navigation routes in general, with both analog and digital maps. Detailed studies also focus on information visualization in the mobile platform and how to optimize a map's usability by improving its visual appearance.

Qualitative research methods for a User-Centered design has been conducted. Including ethnographic interview, user research, and interview, persona hypothesis, and scenario, it is followed by information architecture charts such as card sorting, sitemap, user flow, and wireframes. User Interface design takes precise practices with brand identity, which consists of UI frameworks, logo, and icon design with standard data based on the iOS system.

The thesis final product was an interactive prototype of PicBag, a mobile application that provides textile shopping bags sharing platform. The interactive map is used in there as an essential function for users to track down and find routes to bag stations. The prototype included a simulation of the process of using the map, as well as other features to represent the application's concept.

Both the researching and implementation parts have achieved a certain kind of expected outcomes, although several aspects can be improved. The final product has succeeded in creating maps functions that work well with the application's usability, as well as a visual style that fits the overall UI style.

Keywords

Visualization Map, User Interface, Usability, Cognitive Psychology, Mobile App

CONTENTS

1 INTRODUCTION

Digital interactive maps for navigation have always been a core feature for a huge amount of mobile applications. Given the small and convenient size of the phone screen nowadays, people rely on them significantly for different purposes in daily life routines, from way-finding and moving around in geospatial space to estimating delivery times. A lot of studies have been done in recognizing algorithms based on the spatial and cognitive aspect of the map. The results can be used in optimizing the process of wayfinding and moving around for the user.

A digital navigation map is not only a tool for travelling but also a contribution to the whole experience the user has when using an application. To be more specific, it follows the same interface visual theme and supports users in pursuing their desired outcome or estimates the time for their delivery. During the research part, the thesis will focus on how the basic graphic principles are applied to map visualization. A special concern will also be paid to informative printed maps and charts. Although lacking the navigation function, they provide a huge source of visual impact on digital map-making.

That leads to another issue being discussed intensively in the thesis: How to design a navigation map that holds an attractive visual appearance and at the same time follows the strict rules of cognitive psychology? And how that map would adapt and contribute to the application’s overall structure? In pursuing the answers to these questions, it is important to study thoroughly the different factors from both the perspective of User Interface design and User Experience, as well as the possible connection between them.

The product itself supports a good cause for the environment, with a sustainable solution to one of the world's rising problems: plastic bags. Produced as a mobile application, it allows the user to view and track down a list of reusable bag stations which provide reusable bags for the user's purpose of shopping or carrying goods. The nature of the application's purpose is highly special thus it requires thorough qualitative research on the target customer. User interviews, in-field literature reviews and user testing are the methods carried out to fulfil this mission.

The first concerns following the process of this thesis are the wide extent of the cognitive map. It has been a debatable topic in the psychology field and requires an extremely deep and complex level of studying the human brain. The thesis strives to deliver sufficient resources, which may not cover the entire content of the field, but enough to contribute to the issues related to the final thesis production. Another risk is the outcome itself, as the author only attempts to make a visual prototype of the User Interface for a start-up mobile application. Although all the factors of User Interface and User Experience are studied carefully, problems may occur when programming gets involved in the development step of the application.

2 HOW NAVIGATION MAPS WERE CREATED AND FOLLOWED

In order to design a well-functioning navigation map, it is essential to study the way the human brain receives information related to following routes and geographical recognition. A brief history of mapmaking will be introduced, starting from the very first communication presentation in the form of carvings to hand-drawn illustration and the interactive digital mapmaking of today. To understand and follow maps, certain parts of the human brain are activated, such as cognitive psychology, spatial memory and peripheral vision. Each of the components operates on their own and yet are complementary to each other. As these systems are very complex, the thesis will only analyze them from the aspect of how they affect the user's ability to read maps.

2.1 Cartography and its influences

Cartography is the study of practical arts and sciences in maps making. Maps are visual representations conveying spatial information. Through different techniques combining sciences and aesthetics, geographic data is universal and should be understood by most people from different backgrounds and cultures. Ancient maps also carry cultural and philosophical meanings from their time, as well as scientific ideas and contributions passing from one generation to the next. (Merriam 1996.) Therefore, it is necessary to study the history of cartography and its important changing points to understand more about modern digital maps.

The development of cartography and mapping itself has begun as soon as the first graphic communication mediums existed, such as clay markings, stone carvings, cave painting and drawing (Moreland and Bannister, 1983). Hence, the first map of the world is still a debatable matter. Ancient Greek and Roman Empire were considerably advanced in cartography as their philosophers and scientists had strong influences on the Western social and study. Ptolemy (about A.D. 85-165) wrote one of the first completed official documents on geography showing the “world” with a latitude and longitude system from about 60°N to 30°S. It had a high impact on later geography studies until the Renaissance. The Romans also made suburban maps between their villages with distances and places names written in it (Agrawala 2002).

Throughout the Medieval period, limited distributions of hand-drawn maps were produced in the heavy influence of religion and politics. Explorations and migrations made by enormous tribes helped discover the world. The Vikings went up to North Atlantics, while Jerusalem was drawn as the center of a T-O map. (Aber 2008). Maps printing started around the Renaissance time with carved wooden pieces and engraved copper plates. More charts with navigated routes for sailing harbors, coastlines, mountains, rivers and islands were created. The guide for compass was also added into the maps. Globes were introduced and the first map projection that succeeded in drawing the earth on a flat surface was Mercator’s Map in 1569. Meanwhile, China was getting advanced in drawing a complex system of rivers and villages in their maps.

In the early modern world, maps became increasingly accurate and precise. Countries were taking mapping programs as national research and suburban maps for travelling routes was popular during the 17 – 18 centuries. Maps in Japan around this period were similar to the Western side, except that their commonly used material for maps were a long paper showing entire routes instead of splitting them (Agrawala 2002). 1931 then saw the creation of a revolutionary solution for the modern map – the London Underground by Harry Beck. His different techniques included distorting the actual length between the routines, amplifying the London central with straight lines and vivid colors while still maintaining the correct order of the map's overall geography. It still has strong influences on today's subway mapping.

The world then, with the coming of computers and technology, moved really fast to the phase of graphic maps. Especially when people began to be able to travel around the world easily, route maps can be found in popular tourist destinations. Geographic Information Systems (GIS) and Global Positioning System (GPS) on digital devices made interactive maps easy to access from everywhere. Web-based navigation mapping services focus on providing directions for driving and using transportation to get from one point to another. Close-scale maps, often named strip maps in geographical terms, also provide inspiration for the thesis's final product.

Nonetheless, a map can never be a true representation of the real world. The accuracy of physical distances and precise conditions are only reflected on maps through generalization, estimation and illustration. Even satellite and panorama images lack a certain amount of realistic light spectrums. (Aber 2008.) Yet, just like any other graphic reproduction, maps are ways to communicate not only routes, but also cultural values and historical remarks. They are adaptable and evolvable throughout the development of human civilization. And navigation maps, specifically, is a fundamental element in modern society and our everyday life.

2.2 From analog to interactive mapping

Cartography is an act of combining both art and science, and maps provide not only coherent information but also an aesthetic appearance. The growth of modern technology and digital devices in the past decades then set a new light to the way maps' visualization are presented, under the influence of an interactive environment. Robert E. Roth (pp. 59–115, 2013) defines cartographic interaction as "the dialogue between a human and a map mediated through a computing device to emphasize digital interactions." Differences between an interactive map and an analog map can consist of:

Global Navigation Satellite System (GNSS): autonomously real-time and accurate position to the distance within a few centimeters or meters provided by a constellation of satellites from space. The most popular system now is GPS – Global Positioning System (United States), followed by significant others like GLONASS (Russia), Galileo (European Union), BeiDou (China) and QZSS (Japan).

Geographic Information System (GIS): is a sophisticated computer system that collects, analyzes, stores and displays data relevant to spatial patterns and geography information. They are essential tools supporting a planning or building of community infrastructures. GIScience is a scientific discipline studying the underlying structures and techniques of GIS.

Behaviors of the maps' functions, including animation – the time it takes for a map to react when map readers interact with it, interface information and design showed in different zooming scale

Computing hardware and software used to access and imply maps. A map's interface and interactive behaviors are heavily affected by the channel it is presented in. For example, information displayed by a mouse hovering function on a computer has to be converted in another form when showing on a mobile phone.

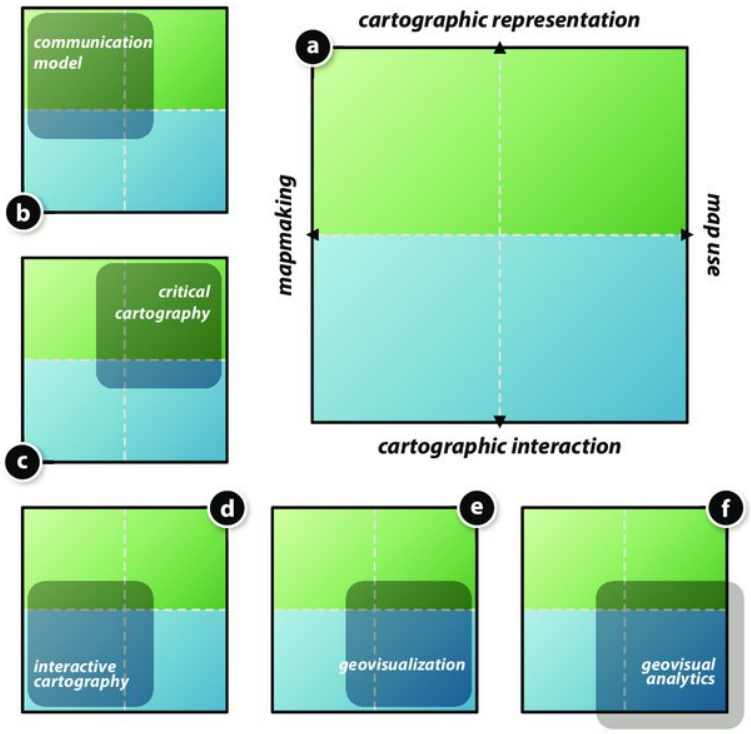

Figure 1. The breadth of research topics related to a growing cartography (Roth 2013)

Figure 1 demonstrates the branches of cartography study, which included overlapped topics from both the analog and interaction map making (Roth 2013). It shows a wide range of potential expands for digital maps related to other studies. Interactive cartography, which has the biggest practices in cartographic interaction and mapmaking, is also the main focus when it comes to making maps in mobile platforms.

2.3 Visual Cognition

Figure 2 illustrates the growths and connections of the three main factors: Mapping, Visualization, and Cognitive Psychology. They are the fundamental topics that influence the thesis research scope. Moreover, their minor departments are strongly integrated with each other. The thesis aims to respectively take them into analyzing in the theory part.

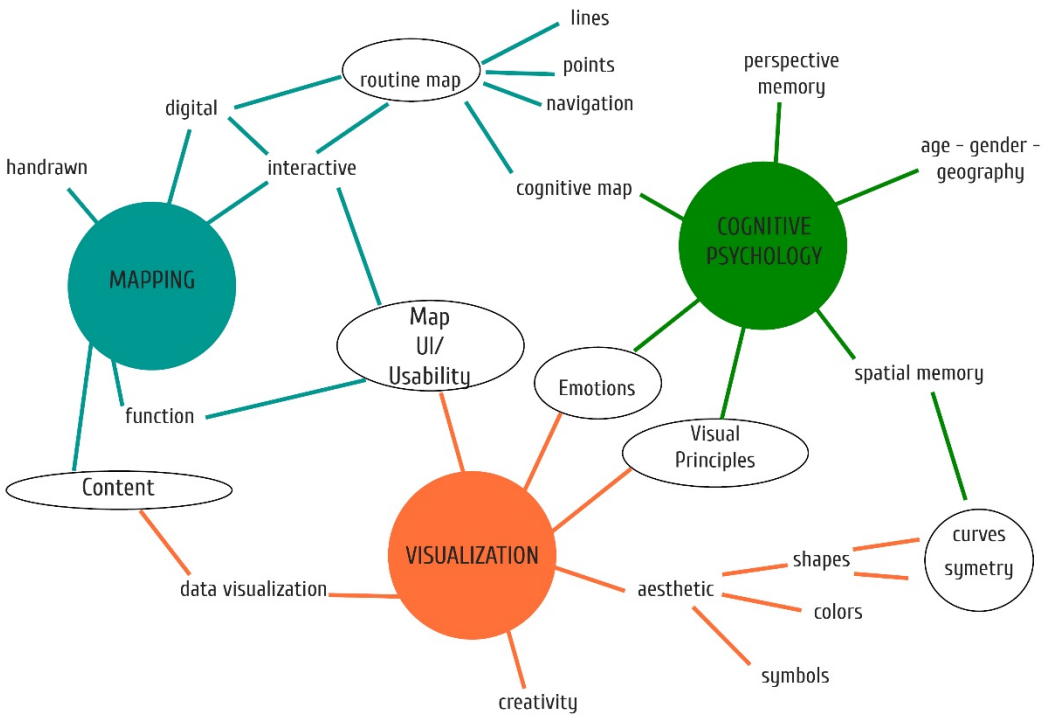

Figure 2. Concept map for research spectrums (Dang 2020)

2.3.1 Cognitive Maps

A cognitive map is a mental map originally described as the awareness of the outside environment and the ability to navigate in a geographical maze (Tolman 1948). When facing a certain situation, the brain will produce an “inside map”, or a representation of the external space (Darken & Peterson 2001). To achieve the best results, not only are cues from the outside environment taken but also the thinking pattern of the brain affects how it will interpret the new information.

Fundamentally, mapping is not only for informative presentations but also for exploration and navigation (Kraak 2014). Therefore, cognitive recognition is active and replied to when a person processes a navigation map. When facing new geographic information, navigators instinctively look for three main categories: points, lines, and areas. Cognitive maps are then being built gradually when navigators continue to analyze and search for those elements. (Agrawala 2002.)

As a cognitive map is built by the person's own awareness of the environmental information around them, it is not always reliable and can contain distortion from personal bias. Yet, it provides enough consistency on geographic and topological information to be used in connecting familiar routes. (Agrawala 2002.) Spatial memory, which is also being analyzed in the next chapter, contributes a big part in shaping one’s cognitive map. (Darken & Peterson 2001.)

2.3.2 Spatial Memory

The thesis addresses this term in both aspects of cognitive interaction with the outside environment and the user’s reaction with digital interface design. In neuroscience and cognitive psychology, spatial memory is the process of remembering and recognizing spatial and space information (Johnson & Adamo-Villani 71: 582, 2010). In other words, if a cognitive map represents a mental map based on certain geography elements, a spatial memory provides guidelines to orient, navigate, or relocate in that map. (Darken & Peterson 2001.) When looking at a virtual map, navigators have to link the map graphic with the spatial memory and awareness from their actual surrounding environment.

In the User Interface Design sense, people tend to expect to find things in a common place for frequent use applications. This applies to both desktop and mobile users. For example, in a large number of application setups, the principle dialogue buttons such as OK, Cancel, minimize, or maximize the screen, are placed in expectable positions. As the mindset (habituation) for those compositions has already created a deep root, an interface with that same rule or even just a similar button in a similar space makes it easier for the user to follow. (Tidwell 2010.)

In some cases, it is also a good idea to make Movable Panels that allow users to arrange and rearrange the tools themselves. It works well for most designing and editing applications but unfortunately is quite uncommon for the map function. Especially for navigation maps, the interactive part that catches the user’s attention is all in the map itself, which contains the actual road and signs for way-finding and route planning. However, certain buttons should still follow the basic

rules of display location to achieve a smooth and effortless workflow (Tidwell 2010).

2.3.3 Peripheral Vision

To study peripheral vision means to consider the function of central and peripheral vision at the same time. Central vision, or fovea vision, takes half of our visual processing faculty in the brain although it only covers a small area directly in front of the eyes. That zone of our vision is very clear and detailed to us. On the opposite, peripheral vision captures a much wider viewing area, everywhere besides the zone of central vision. Our brains can process them at pretty much the same time. As we do this unconsciously, we usually don't realize that it was the peripheral vision that actually supports and guides the eye to focus on what is in the central vision. (Weinschenk 2016.)

On a desktop platform interface, peripheral vision holds an essential role in defining where and how the designer wants the user's focus to be directed. Key areas are the top of the page where there is a navigation bar, the footer, and the two side margins; everywhere that is not in the center of the screen. The image humans get from peripheral vision is blurry, it focuses on the general visual information rather than particular and specific features (Weinschenk 2016). Therefore, it is helpful to fix common buttons and signs in those places.

In figure 3, the peripheral vision on both sides is used to direct the eyes to the central vision with the main information in the middle. In the mobile phone interface design, it is essential to keep in mind the sizes of the screen. As the size is much less than a desktop screen, the spaces allow for central and peripheral vision, therefore, get scaled-down as well. (Weinschenk 2016.)

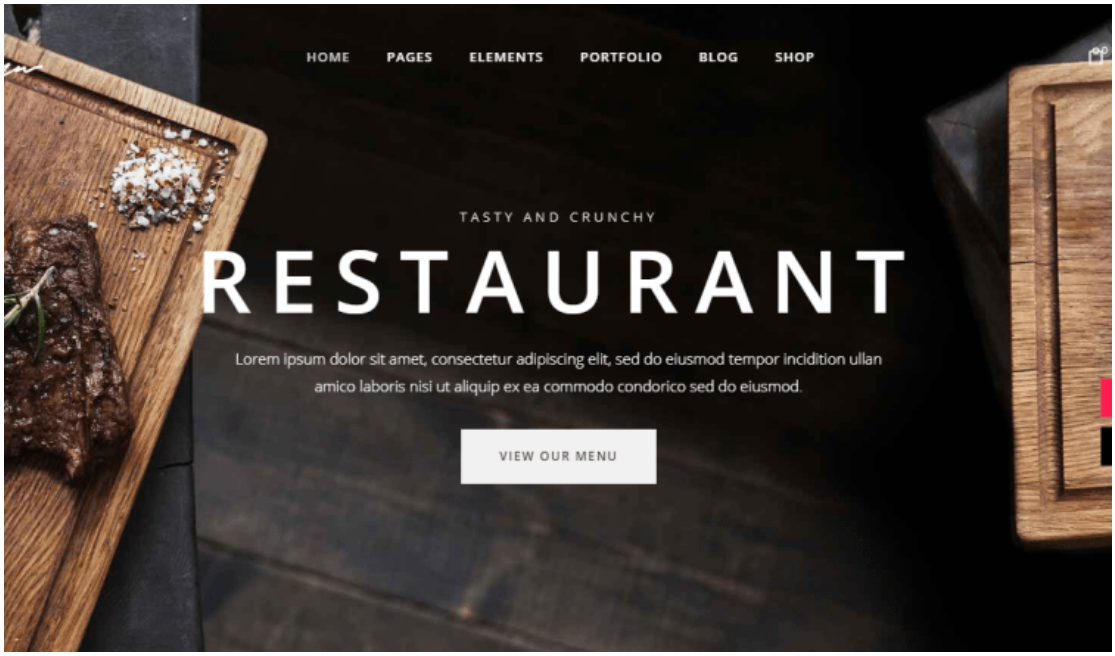

Figure 3. A good use of peripheral vision in a website (Wordpress 2019)

3 INFORMATION VISUALIZATION IN MOBILE PLATFORM

It is undeniable that mapping is a big part of the graphic world, in terms of communication and information visualization (Figure 2). Interactive maps usually contain both texts and images for providing instructions and their overall data in visual form. Whether it is through a mobile phone screen, desktop, or any other devices, principles of visualization and aesthetic are essential parts in building a well-functioned interface. However, it takes more than that to achieve the best possible response from the user. The key is understanding the target customer and modifying the most suitable design for them (Weinschenk 2016). In this section, the thesis would, through brief introduction and illustration, demonstrate the different aspects of data visualization in mobile platforms.

3.1 User-centered design

To distinguish how an application looks like, it is essential to design how it feels like first. This is where the User Experience steps in. Methods of user-centered design approach are analyzed in searching for resources supporting the implementation process. Then, the steps are applied in the making of a mobile application’s prototype.

3.1.1 Qualitative research

Before getting into the creative process, it is fundamental for designers to have a coherent and specific vision of the project in general, along with all its problems and goals and especially its users. A product's design outcome should be ultimately evaluated based on its success in meeting both the project's and its user's goals. (Cooper & Reimann 2003.) Different types of qualitative research can help designers find out and fill in the big picture of their product. This section will introduce some of them, including methods that are used in the implementation part of this thesis.

Ethnographic interview: to not be confused with the definition in anthropology, ethnographic interviews as a qualitative research method means conducting a series of one-on-one interviews with users or potential users while making observations of the user's reaction and behaviors in their natural settings or environments. Both open-ended and closed-ended questions are asked in different stages of the interviews to clarify the motivation behind the users' actions as well as confirming and adjusting any assumption the interviewer had. The author planned on conducting one interview in the process of implementation but failed to do, yet there is still a user interview, which provided detailed insights to potential user groups without any environmental observation. (Cooper & Reimann 2003, 46.)

Persona hypothesis: attempts to define different kinds of users and their motivations. User goals are presented through personas goals, then designers can focus on making that goal easily accessible via enjoyable steps. Personas' backgrounds are built according to the information collected in the user interview. Nevertheless, it is necessary to keep in mind this method concerns criticisms due to its questionable practical and psychological issues, hence the results are not entirely reliable and designers should consider alternative directions in some cases. (Cooper & Reimann 2003.)

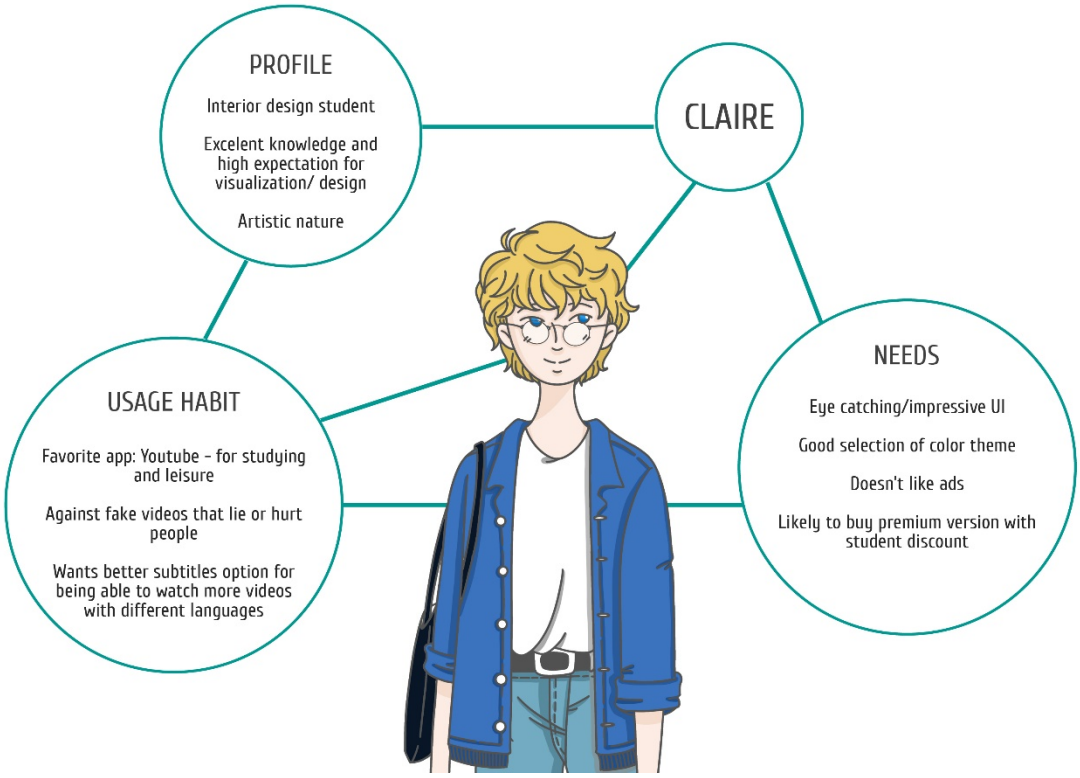

Figure 5. Persona and the related background information created for PicBag (Dang 2019)

User Journey Map: is a visualization of different scenarios that users are expected to meet when using a product or service. It usually contains a specific persona, their goals, and different stages they go through to get it. Different emotion points are also created based on a person's engagement and expectations with the product: a pain point when facing a struggle, touchpoints when the product offers solutions for it, which leads to positive or negative results in users' emotions and experience. The goal of making a user journey map is to define typical user's usage patterns, clarify or narrow the problem statement, and adjust the product's features for it. (Rajani 2018.) The author finds it helpful for envisioning and establishing the site map and framework later.

3.1.2 Information Architecture

After having defined and enough information on the product's directions, it is time to build a structure of fundamental information and content organized clearly and coherently. This process is under the study of Information Architecture (IA), which is a crucial part of designing web-content and mobile applications. A logical IA

design allows uses to get to their desired destinations as easy and as quick as possible, it also provides a consistent framework for designers to follow later.

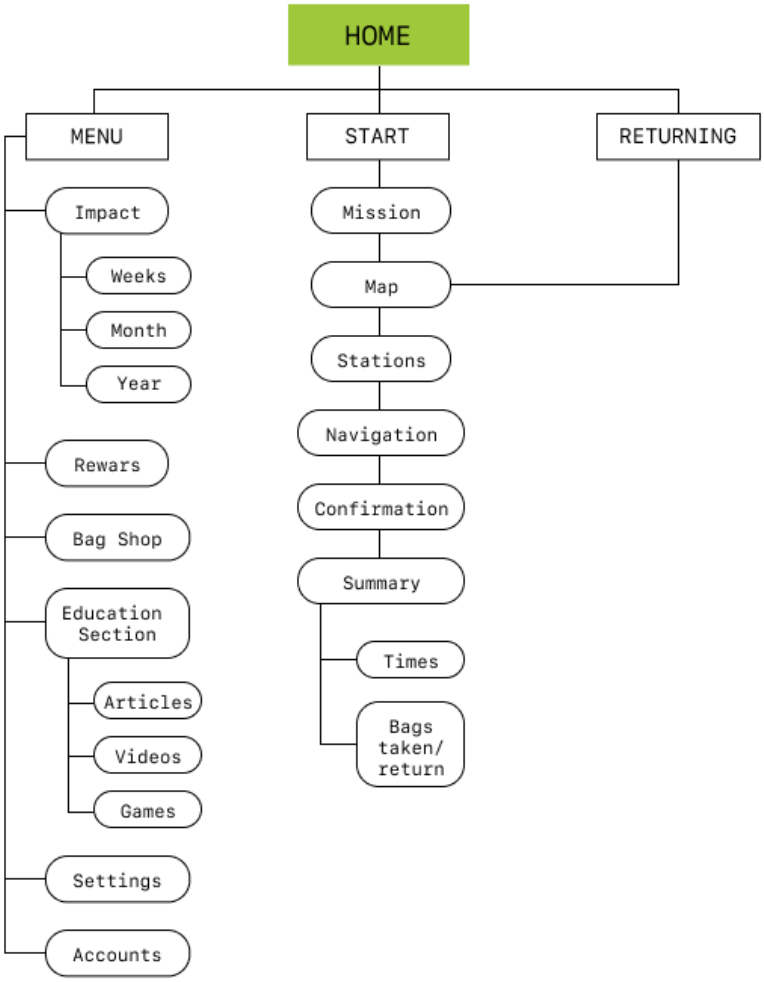

Figure 6. Sitemap for PicBag (Dang 2020)

The first thing to do when building the structure is listing contents. At this stage there is no limitation or restriction, all ideas are welcomed as the broader the list is the better. They should be listed into groups of different categories or levels depending on their types. Designers can choose to sort the information with a method of LATCH, which stands for Location, Alphabet, Time, Category, and Hierarchy. Also known as “The Five Hat Racks” principles set by Wurman (2000), it is an effective way to organize data and represent information. Priorities then are taken into account due to the importance of each content. Card Sorting or Tree Testing are good methods to help with this stage. New applications or

websites should use Card Sorting while already existing ones can use Tree Testing.

With the sorted content, sitemaps can be used to visualize a navigation backbone. Relationships between contents as well as a logical overall hierarchy should be mapped out distinctly (Brown 2011). Different shapes and nodes for each opponent can be customized for a maximum visual effect (Figure 6). A flowchart, or sometimes called user flow, reflects how users navigate their way through the system. Unlike the sitemap, components in a flowchart have arrows between them, dedicating the process of particular functions or tasks (Appendix 4).

3.2 Affordances

"Controls should be where they ought to be." – Donald A. Norman, 9-12

And also they should look as to how they ought to be. As we have already learnt some insight in the way the human uses their cognitive thinking, it is crucial now to acknowledge how one product's appearance is its own instruction for using (Norman 2002). Defining the affordances term, Norman states that it is the perception of an object's purpose from mere observation. When using a product with well-prepared affordances, users may not have to read the instruction at all. In the User Interface design, affordances can be decoded into consistency, in which visual elements have certain patterns that makes it easier to use. The less time users spend to adapt to new applications, the more time they have to explore and really enjoy it. (Apple 2020; UXPin 2015.)

Since the first iPhone was introduced to the world in June 2007, humans have then been using and getting familiar with the small screen for decades. Even before that, the evolution of computers has brought us to the new era of the electric screen and digital interaction. Just like the fact that a chair is mainly to sit on, the human brain developed "mental models" for a list of common visual clues when using digital devices (Norman 2002). One of the most classic examples may be the asterisk, as almost everyone recognizes it as a sign of mandatory. It

is an essential part of any online form or application. Without the asterisk, confusion would arise when users questioned themselves about the priorities of the questions.

Another great example of common interface buttons is the three stripes menu button, also known as the hamburger button (Figure 7). Despite having conflicting opinions about its advantages and disadvantages, the iconic menu is undeniably popular among smartphone users. In almost every application, it can be found on the top left or right, indicating that there are more choices within.

Figure 7. The hamburger menu icon and its use in mobile interface (Dang 2020)

To take away, consistency in visual design is very important and should be retained as much as possible. Especially for common-used elements like buttons, icons, or links, the closer they look to an industrial standard, the easier it is to recognize them. As people use semantic memory to remember continuously repeating facts, designers should make the important things easy to encode and process. (Weinschenk 2016.)

3.3 Interaction Design

Being part of the whole UX spectrum, interaction design is a combination of other designing disciplines, including visual, sound, and motion artifacts (Silver 2007).

While it applied for a wide range of systems and environments, in this thesis the term is used to describe the creative process in making web and application products. Interaction design focuses firstly on behaviors and interaction between the software and people, rather than just one-way expression like traditional visual mediums. The user becomes a subject instead of an object to be looked at. Therefore, when making interactive components, designers always have to keep in mind who is their users and how their backgrounds will affect the way they interact with the products. (Cooper & Reimann 2003).

According to Gillian Crampton Smith (Designing Interactions, 2004) with addition to Kevin Silver (What Puts the Design in Interaction Design, 2007), there are 5 principal dimensions to help define and develop interaction design concepts. Smith herself used the word “new languages”, which reflected/indicated the closeness those terms have with previous design definitions. Years after, they have gradually become more recognizable in the designing world.

The first dimension is words, which should be simple and short enough for the user to understand. In a mobile application, that implies for button labels, feature descriptions, instructions, and additional information supporting the application’s content.

Second dimension: visual presentation. Taking inspiration from a painting’s perspectival and compositional representation, it concerns graphical elements such as typography, icon, logo, diagrams, and information graphics. Together with words, they communicate direct and important messages to the user.

Third dimension: physical objects or space. This means the physical products or environments that users interact with or within. The mobile phone itself consists of affordance for its fingers gestures and taps, as well as its usual screen dimension and automatically built-in features. Designers should take this in extremely concern when making interactive elements.

Fourth dimension: time. It included sounds, animations, and videos as those media are displayed within a certain time period. While they all have significant impacts on the user's senses, animation specifically is a powerful dimension when it comes to mobile screens. When being used correctly, it brings more harmony to both the visual content and the user's flow.

Fifth dimension is behaviors, which consist of the user's actions and operation on the product as well as how the product reacts within the dimension mentioned above.

A thorough study of interaction design is also extremely important for making prototypes that represent the product's ideas correctly and clearly. Especially for the thesis outcome, when actual GPS and map functions are not ready yet, motion design will be relied on to bring the best result concerning the interactive map feature.

4 INTERACTIVE MAPS IN MOBILE APPLICATION

4.1 APIs and SDKs for maps in mobile application

Because of the thesis's focusing on visual interface design, only brief introductions on the development stages are written. When a mobile application wants to imply map function, most of the time there are two things they need to cover: geolocation and navigation. Geolocation is a positioning service which detects and shows users' continuously updated location in the map. Meanwhile, navigation gives descriptions on how to get from one point to another. As it is almost impossible and unnecessary to develop everything from scratch, SDKs, and APIs from mapping service providers are used.

SDK, Software Development Kit, is the applications' software development sets designed for specific hardware platforms and operating systems. Whether in iOS or Android, it provides various tools supporting efficient and faster development. Meanwhile, an API stands for Application Programming Interfaces,

Unlike SDK, APIs are cloud-based services that operate as communication between client requests and the server responses. It defines how software components interact with each other.

At the moment, Google Map dominates the mobile industry in terms of native mapping services providers as well as SDK and API host. It has a massive database and information that covers a wide range of geographical interface and map styles. When implemented on IOS or Android, their SDKs allow developers to display the maps directly from Google Map data to the application. The APIs would then take care of the rest, from access to the main serves, detecting locations to interactive features. Having a massive database and information, it also covers a wide range of geographical interface and map display styles (Google 2020). One outstanding alternative option to Google Maps is Mapbox, which has a relatively small coverage yet is less pricey and offers interesting customized options for map style. It is highly recommended to consider between them based on the application's goals and needs.

For the outcome product of this thesis, due to limited resources and the main focus on visual design, no integration or database is added. Instead, the prototype shows an animated flow of navigation map that presents very closely to how the actual map will work. This solution is also suitable for an MVP application that should not spend too much on the developing stage yet.

4.2 Case studies on interactive map feature

Plenty of mobile applications nowadays are using digital interactive maps as one of the core elements in their system. The map can be an essential tool for users to achieve their goals or is the main function itself. Either way, it requires a high-quality investment from both the visual design and content writing departments. This section attempts to analyze the way interactive maps UI and UX were designed in Uber and other scooter sharing applications. The studies use data collected from the companies' designers' blogs, as well as online reviews from users and press resources provided in the companies' websites.

4.2.1 Uber

Uber is an American company that offers ride-hailing service through the mobile platform in over 700 cities. Their offers also contain ride-sharing, food delivery and self-rent electric scooter and bicycles in some areas. Officially founded in 2011, the mobile application numbers of users increased significantly and by 2016, it delivered over 3 million rides a day. Locations and navigations are fundamental functions to the app users, including both driver and rider. This analysis part of the thesis concentrates on the design of interactive maps before a ride starts and its effect on users' satisfaction.

To start with, the application gives the riders full authority to choose between taking full control of choosing their pick-up locations or using smart navigation options. Either way, riders' agency is very respected and the system is automatically adjustable to their needs. For example, the first thing a rider sees when opening Uber is the question "Where to?" – then they can type the whole address in or set a pin on the map. The GPS does the job of recognizing the user's current location, yet they can always go back and adjust it if needed. Locations of available drivers in the area around are also visible, with reasonable numbers of around 3-4 cars at a time. Familiar destinations like Home, Work or Gym are remembered for quick actions.

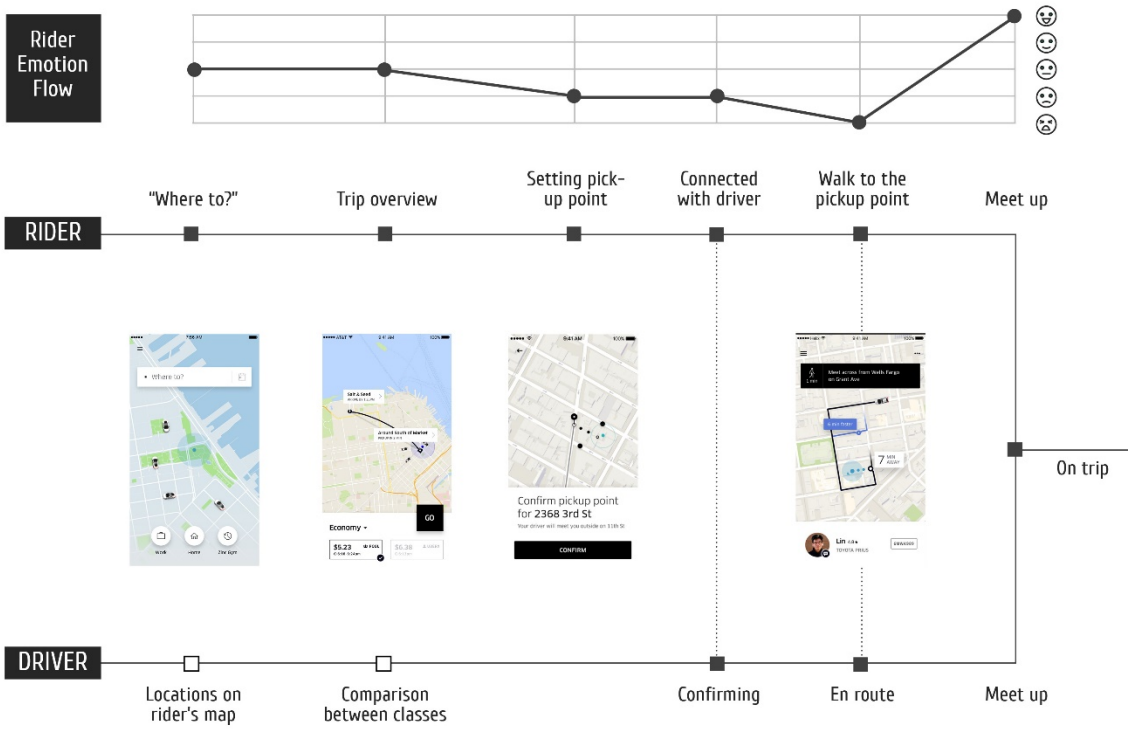

Figure 8. Uber's Map Design and User Flow (Dang 2020 and screenshots from Pan, 2016)

As illustrated in Figure 8, the step when users have to walk to the pickup point can be quite frustrating. Various factors can affect the success of a pickup, ranging from the destinations' locations, confusing nearby streets and neighbourhoods and communications with the driver. Therefore, considerable tools and options were designed in the maps leading to that step, in order to prevent possible problems that could occur. When riders set their destination, the screen will display a visual animated flow representing the trip overview, as well as options for different car types. By adding this extra smooth step, the application gives users an overall vision for their journey. Differences between car types such as arriving time, price and vehicle brands are also displayed clearly.

During the picking up, the map interface shows the distances between users' locations and the related important components: pick-up point and the driver's location. It makes sure to highlight the differences between routes by applying different motion design to each of them: route by car estimating the distance between rider and driver is straight thin lines and walking route from the rider's location to pick up point is dashed lines. Moreover, when describing the pickup

locations, the map does not just state the actual address, but it instead uses a wayfinding framework called Geotalker. The framework conveys geocoded streets number and names into a phrase mirroring how the human cognition reacts with spatial information and casual wayfinding communication (Pan 2016). For instance, the sentence “Meet near 200 Drum St outside Pauline’s pizza” described the place with additional information that makes it easier for riders and drivers to find each other.

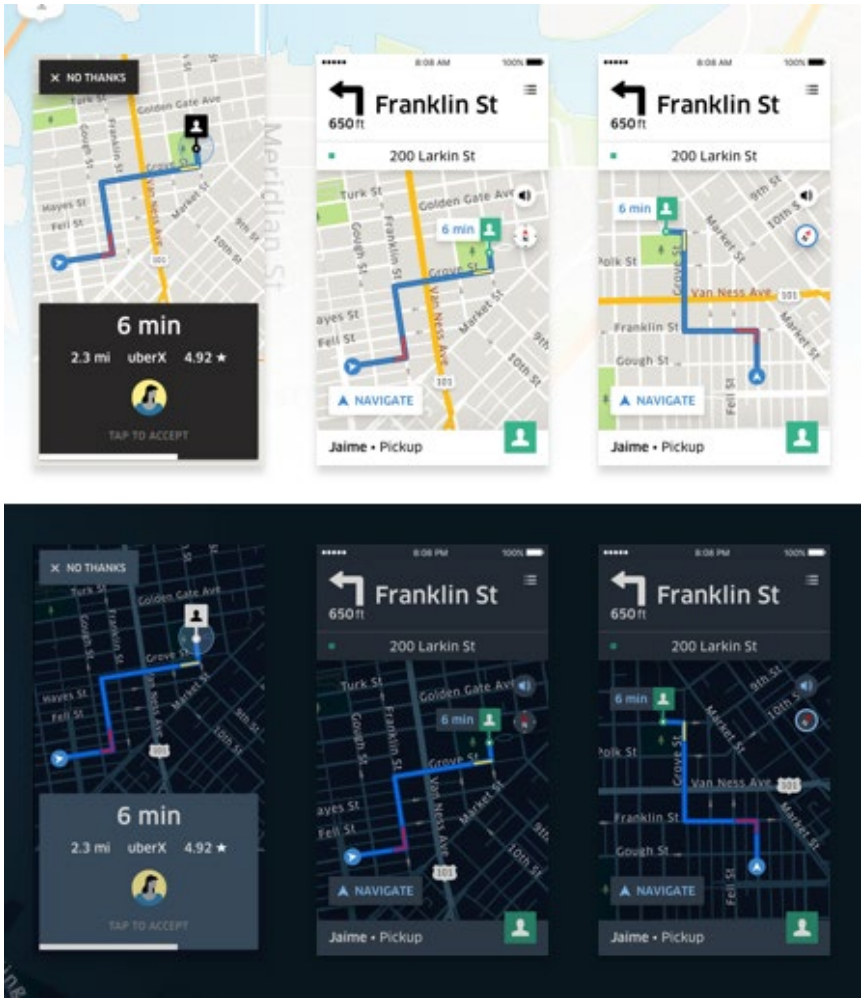

Figure 9. Uber Day and Night Mode UI (Wachsman 2017)

On the driver side, extra attention in UI design was paid due to the exclusive mobile screen’s view when driving. Drivers usually only have a few seconds to glance at the screen and limited taps for buttons. Simple gestures such as single tap and slide for confirming actions were created, along with customized cartography motion design and distinctive packages of visual components for

different parts of the trip. Due to frequent night trip requests, a separated night mode for driver interface is also available (Figure 9). It offers a darker theme on the map styles and UI to decrease possible light pollution and improve visions of the road. (Wachsman 2017).

Overall, different factors in a ride affect different stages in the user emotion flow. Connecting or waiting for a driver to confirm can cause stress and dissatisfaction. Depending on the time and place, it is common that users may have to wait a long time or get cancelled from drivers. While that issue lies in external unexpected situations, the map itself helps reduce tension by offering GPS tracking. The driver's location is updated continuously so riders can see and estimate the time they arrive. Despite the risk of cancelled trips, it is reasonable to say Uber has done a decent job in designing interactive maps supporting wayfinding and interaction between its parallel users.

4.2.2 Scooter sharing applications

Starting as California-based start-ups in 2017, scooter sharing applications have created a whole new system of transportation on a worldwide scale. They all provide vehicle-sharing services with dockless bikes, electric bikes, and electric scooters. Customers use their mobile platform sites to track down, unlock vehicles, and payment. Even though different companies have taken on the business model, in terms of map design and function, they all, in one way or another, operate the same practice. Three applications were chosen to analyze in this section, including Lime and Bird, two of the earliest and biggest providers from the United States, and VOI from Sweden.

Interactive maps are core features in the products, including travelers' and vehicles' global system location and navigation. Integrating, they are extremely important in the stages where users have to look for and unlock their desired vehicle. As seen from Figure 10, Lime's "homepage" is also its map for bikes and scooters locations. It takes the user straight to the main task: looking for an available vehicle. The application's colors theme is used effectively in highlighting important features and directing the users' eyes to where they should look. The

map elements themselves are presented in monochrome greys, while the locations of bikes and scooters are in green and restricted areas are red. Moreover, cluster areas that have a high number of bikes get a glowing green indicating that users can zoom in to look for more. Battery status is displayed on each bike icon for quick eye scanning.

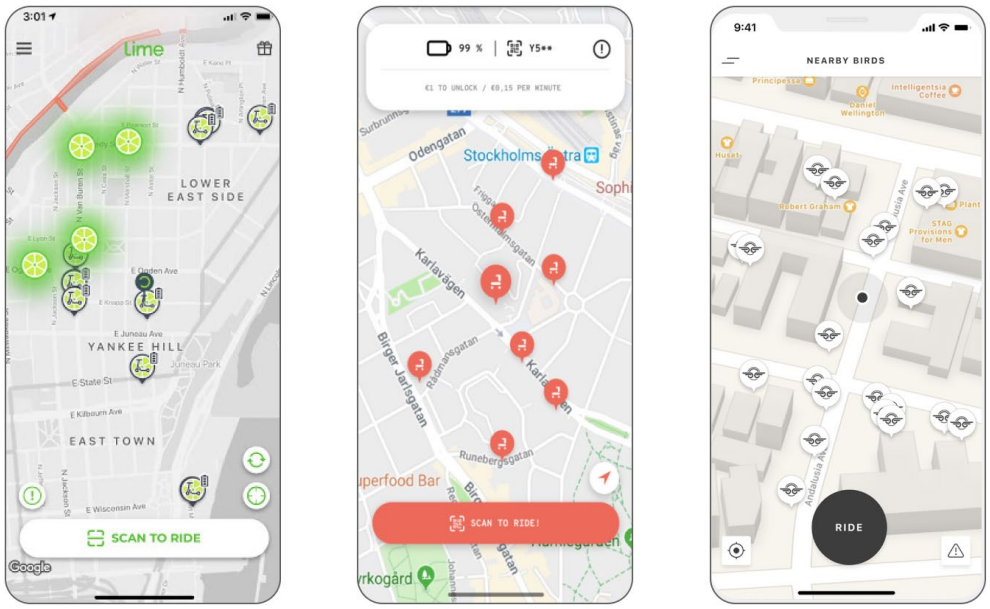

Figure 10. Screenshots from Lime, VOI and Bird application (Lime, VOI, Bird 2020)

Meanwhile, VOI uses the same monochrome color map but does not show battery or numbers of bike information on the overall map. Users can only check them once they tap on the scooter location icon. Bird's original logo has wings on two sides and for a while, they have used it for station locations, which caused confusion and inconvenience when looking from a mobile screen. Hence they changed it from the current updates and it has been so much better visually (Figure 10). The three applications have a consistent color theme as well as round-shape icons and buttons. They catch the users' eyes rapidly and provides a better overall view. It also brings up the feeling of convenience as users can already see the bikes they can take, even when they don't know exactly their locations yet.

In March 2019 Google Maps had added Lime to the routine planning function. Users now can see available Lime vehicles and time to reach the destination inside Google Maps, as well as the total time if combining Lime and other public transportation. The integration is a thoughtful and logical act on improving the applications' usability: users are provided with more options which can help their travel get faster and more affordable. Other integrations also happen with Uber and Lyft when they both have their scooter-sharing branch.

5 PRODUCTION OF MAKING USER INTERFACE FOR MOBILE APPLICATION

5.1 Ethical aspects and inspiration

Debates and discussions around the issue of plastic trash have been happening for a while as part of the environmental raising crisis. Concerning the inspiration and idea for the implementation part, two matters will be mentioned: current plastic trash numbers and its alternative solutions comparison. In January 2018, China – which handled nearly half of the world's plastic recyclable trash – banned the importation of less than 99.5 percent pure plastic disposal (Parker 2018). This means most of the trash is not accepted, especially shopping bags as plastic bags are highly difficult to recycle due to their various colors and chemicals (Bratskeir 2019). That left a lot of high-income countries, including Japan, the United States, Germany, and others in Europe scramble to find new ways to manage their waste.

Plastics itself have an intense and extremely high carbon footprint life cycle. From the very first stage of extraction and distillation from resins and fossil fuel to when recycling, incinerating or composting, it takes up a significant amount of energy and carbon dioxide discharged. That counted also transportation during the process. 2015 saw a total amount of 1.8 billion metric tons of CO2 from plastic emissions. (University of California 2019.) The consequences and damages are countless, from killing ocean animals to contributing to global warming. To sum it up shortly: "Plastics crisis is a climate crisis hiding in plain sight", said Carroll Muffett, president of the Center for International Environmental Law, USA.

However, alternative solutions are not providing much better scenarios. When it comes to the number of materials including electricity, water, the fuel needed for producing, paper packaging does take more space than plastic. Other substitute materials mix also have bigger impacts on the climate, as plastic is light and needs a shorter process to produce. (Joyce 2019.) Therefore, simply replacing plastic bags with other materials such as paper and fiber may backfire. However, the term “reusing” has the opportunity to create positive outcomes in the scene.

Belonging to the Waste Hierarchy chart, Reuse comes second after the Reduce/ Prevention in priority in waste management that brings benefits to the environment (Waste (England and Wales) Regulations 2011). It means before considering the recycling procedure, reusing should be taken into account. Describing as “checking, cleaning, repairing, refurbishing, whole items or spare parts” (Waste (England and Wales) Regulations 2011), reusing helps saving energy and money to produce new material, which also leads to zero waste being discharged into the climate.

In Finland, 860 million plastic bags were used in 2018, which were 90 million less than the year before. The recycling numbers are also considerably high, with an increasing percentage in recent years. (Yle 2020.) In addition, different companies and organizations have taken action on promoting sustainable living style. Lindström Group has just opened a new service with returnable shopping bags, cooperating with supermarkets to rent them out at check-out counters (Lindström 2020). “Muovipussiton Kerava” - “Plastic Free Kerava” is a movement founded in 2019 in Kerava, which creates and organizes events supporting a plastic bag-free environment. They provide workshops on how to reduce the use of plastic bags at home, such as categorizing recycled trash more effectively. Cooperation with other companies to produce commercial fiber bags and delivering free bags to various households were also made. (Muovipussiton Kerava 2020.)

The movement is a big inspiration for the thesis implementation part's idea. Digital products in a mobile platform is a great way to connect people and communicate positive messages. An application that allows people to track down and collect textile bags from different stations in local supermarkets seems to fit the current demands and situation in plastic bag free movements and projects in Finland. Statistics mentioned above also show that Finnish citizens already have suitable tools and mindset to accept new approaches. Interactive maps visualization comes to picture as it is an essential feature for the application purpose. Finally, the primary purpose of the product is not to stop the plastic bag usage in everyday life, but rather to emphasize the sharing process between citizens and reusing textile shopping bags.

5.2 Maps UI and Usability

After doing different methods of literature reviews, case studies, and theory research, the author has analyzed and concluded the results into different factors that may help improve the Map UI and usability.

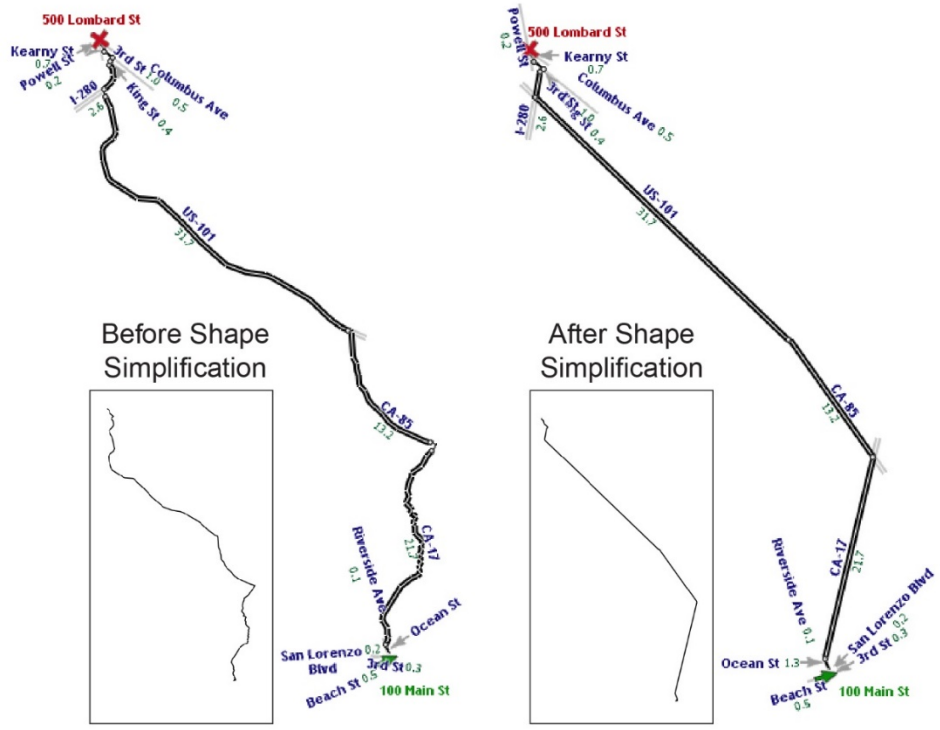

Figure 11. Before and after shape simplification for a strip map. (Agrawala 2001)

Shape Simplification: when conveying geographic information into 2-dimension visualization, different techniques are applied to make the content either more authentic or legible to the reader (Figure 11). Smoothing curves, interpolation, and simplification take away irrelevant details and create straight lines that are easier to follow and navigate (Agrawala 2001). During the generalizing process, the scale and ratio of the overall topology should still be maintained.

Consistency in icon design: clear clues should be given to particular elements: the destination, user own location, search tool, and main options concerning the map. (Appendix 6) Mapping always has particular standards for those and consistency ensures that those demands are in an easy place to find and reach (Figure 12).

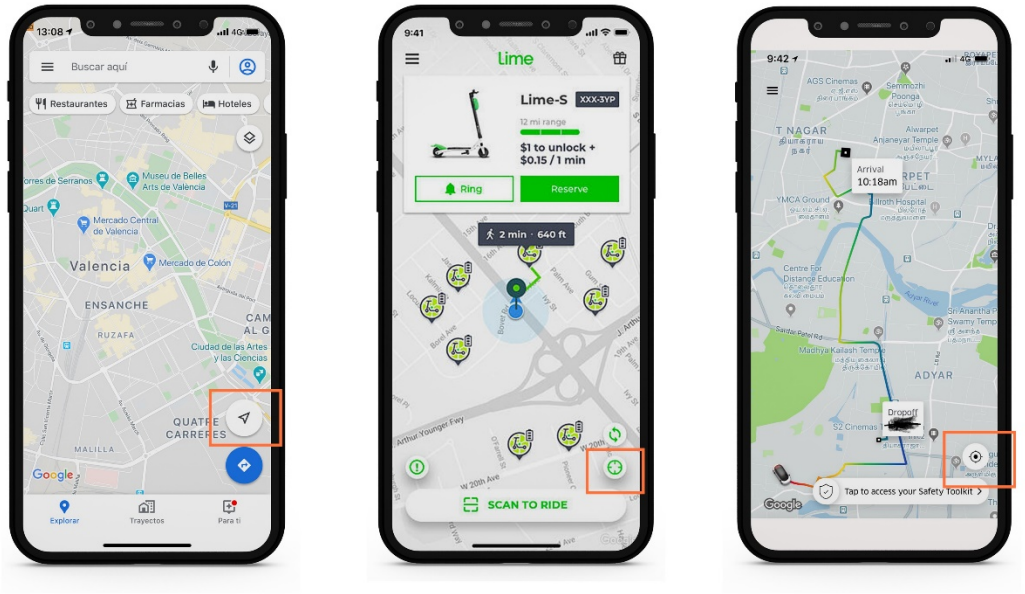

Figure 12. “Your location” common button in mobile maps (Screenshots from Google Map, Lime and Uber 2020)

Motion design: is an important feature to improve a map’s usability. When applying to the navigation flow route, it represents an overall view of the journey, which helps users get faster and easier in defining and planning their trip. Especially with mobile applications, animation guides the users’ eyes to important

factors in a limited screen space. However, color and size choices should be considered carefully as clusters or too much contrast can have a negative impact.

5.3 Defining the application's goal

Three different acts concerning the methods of User Interviews and Personas were carried out. Although all of them were conducted online, the questions and answers were studied thoroughly for the best insights into the potential users' characteristics and directions that the thesis's product should follow. The goals for each performance respectively are: updating the current plastic issue bag usage issue in Finland and the citizen's opinions, getting users' feedback on interactive map styles, and background user research towards the target customer group.

5.3.1 Ethnographic Interview and User Research

Firstly, a one-on-one interview was conducted with Granström Mari, Chief Science Activist, and Founder of "Plastic Bag Free Kerava" movement. Even though the movement is only operated in Kerava at the moment, its system, directions, and customers are great models to study for the thesis's implementation part.

When given insights on individuals and organizations associated with the project, the founder has pointed out a few things: the main channels for informing and updating the project have been the local newspaper and an online group on Facebook. As most of the active responders are people from the age range between middle-age to seniors, digital platforms usage has not been considerably popular. Hence, offline promotions such as posters, banners, and counters in local supermarkets also have important impacts. As the topic of plastic bags is still widely underrated and misunderstood with debatable discussion, it can be an explanation of how people prefer to communicate face-to-face to get involved in the project.

A majority of Finnish citizens were also found among the participants of “Muovipussiton Kerava”, which is quite noticeable from the fact that most information on the project’s website and Facebook group is in Finnish. However, it is ideal to add other languages such as English and Swedish in their media channels in order to approach a more international environment. In a way, it is a goal that the project attempts to achieve in the future.

At the moment, “Plastic Bag Free Kerava” has five stations in local supermarkets that offer fiber bags for sharing. The bags are produced by Paptic, a Finnish packaging company. However, they face a problem of one-way takings of the bags. Most people stop exchanging and keep the bags for themselves. However, Mari believes that it is possible to solve the problem with a better channel that gives educated information on the current plastic bag waste issue. The lack of guidance and commitment makes it easy to not evolve in the sharing process. That leads to the creation of “Plastic Media” section in the product, which provides articles and helpful instruction

Secondly, an online survey was sent out for Google Map mobile application users. It included questions about their preferences on the map styles, as well as their evaluation of a specific map’s features. illustration photos are screenshots taken from the Google Map application. The primary goals of the survey are to find out if Graphic or Satellite map style is used more frequently and its reason. Out of 26 participants from different regions and ages, more than 90% stated that they prefer to use Graphic Map style and almost 60% of their reasons are out of habit and easier to use navigation systems (Figure 13). Even though the numbers of answers are not high, the significant gaps between the two options have made the survey result considerable.

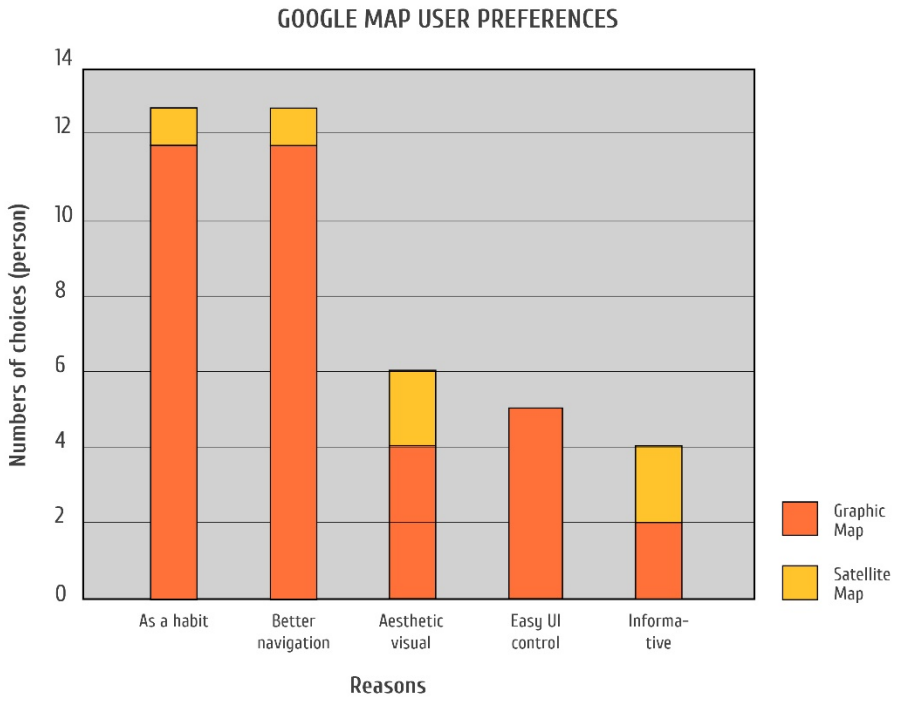

Figure 13. Google Map User Preferences between Graphic and Satellite Map chart (Dang, 2020)

Looking back from the research of visual cognition and affordance related to interactive map visualization, the map styles survey results can be explained in one possible meaning: when following routes, people tend to use their spatial and cognitive memory unconsciously. The same thing happens with mobile application interfaces, visual affordance holds an important part in making a smooth and enjoyable user experience. Therefore, when a person uses a certain kind of map frequently, they get used to the visual appearances and propositions of the interface. It makes a big difference in terms of time-saving, wayfinding cognition, and personal emotions. Everything is easier to control when all the buttons' positions are clear and similar.

In conclusion, when map users choose one map style over another, it is not because of technical reasons but rather depends on the user's personal experience and usage habit. Since most of the participants belong to the target groups of the thesis final product, it is undoubtedly that a graphic map is more suitable to use as an essential feature.

5.3.2 Personas and User Journey

Customized interviews with potential application users were sent out online. Its purpose is to collect information and ideas to build personas (Appendix 3). Due to the exclusive of the topic, only 6 people receive the interview, and personas were created on each of them instead of combining them from various answers. During the interview, two main issues were addressed: the first one included the participants' personal lifestyle with closed-questions about their day-to-day activities and routines, some of them related to using the digital product and some of them are not. Altogether, they helped to form the personas' backgrounds, characteristics, interests, and their habit of using smartphones to access digital services.

In the second part, participants were asked to pick one application that they either use or like the most on the phone. The questions then focus on the reasons for their choices and evaluations of the product. With open and multiple-choice questions, the interview attempted to explore the user's opinions and impressions on different factors. It included the user's self-motivation and reasons, their usage habits, and dependence on the application, as well as ratings on its function and features. Even though the participants' choices are from different fields, they still indicate what the users are looking for in a mobile application generally.

Unlike the first survey, where participants' background does not affect their choices on preferred map styles, this customized interview revealed the connection between a person's educational background with their experience using digital products. Art and design students and professors tend to appreciate an overall visual appearance of a product, such as its UI, color choices, or distinctive style and concept. One participant, who refers to himself as a "computer geek", values the application security and privacy the most. It is an interesting point to see in terms of web-cloud communication.

After getting to know the target customer and the insights on what they are looking for, personas, and persona charts with theoretical scenarios were

created. Three personas were created with background information divided into sections of Profile, Usage Habits, and Needs (Appendix 3). One of them was chosen to set up a User Journey Map (Figure 14), which focuses on the possible steps users may face prior to using the product. The product's features will be built as solutions for unpleasant situations that occurred.

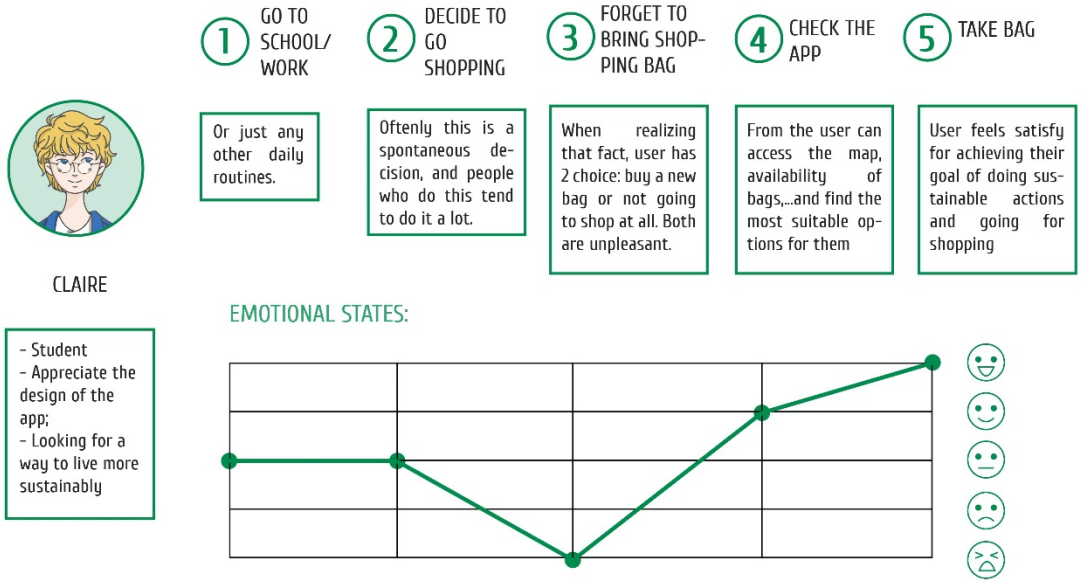

Figure 13. User Journey Map – the chart indicates the changes in user's emotion concerning the situation when using the map (Dang 2019)

5.4 Framing the content and structure

5.4.1 Card Sorting and Sitemap

To start building the application structures, different methods such as Card Sorting (Figure 15) and Site Map (Figure 6) were applied. With the Card Sorting chart, all fundamental features were listed in 3 different big sections: Basic Features, Motivation, and Map Function. Some features were created based on the interview with Mari, founder of "Plastic Bag Free Kerava", such as the Education Section, which contains helpful instructions links and Impact, which states the amount of carbon footprint of plastic bags. They are listed together in the Motivation section.

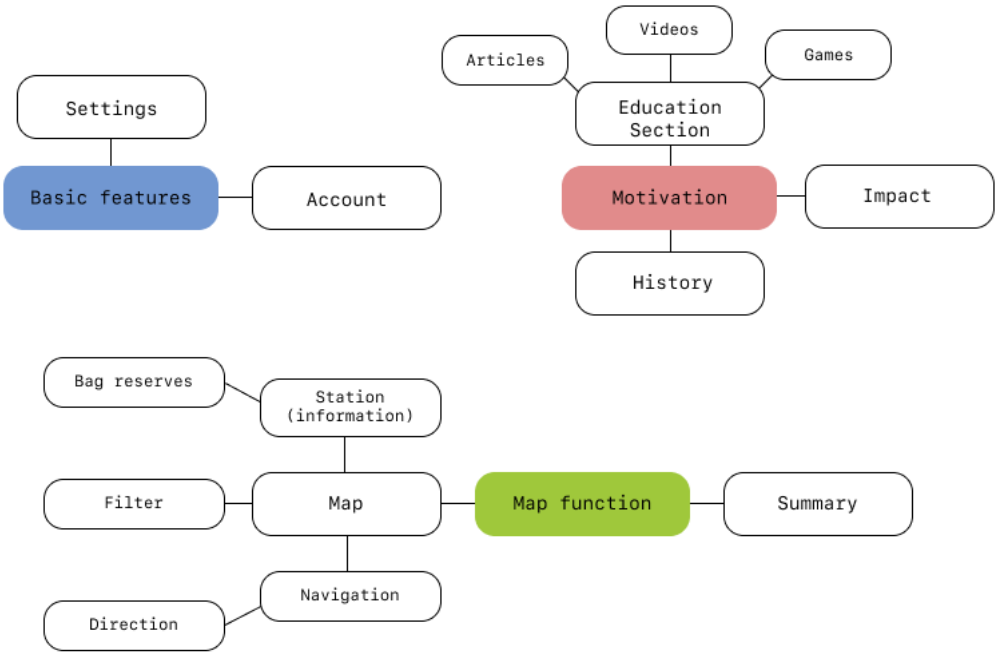

Figure 15. Card Sorting chart for PicBag (Dang 2020)

Menu functions such as Your impact, History, and Plastic Media are all low priority, compared to the main map function. However, altogether they create a better insight into the application's content and idea. Therefore, the author decided to keep them as informative and interactive as well. With the sorted features from the Card Sorting process, a Sitemap was created to organize the priority and order of them (Figure 6). It presents where and how the features are connected with each other.

5.4.2 User Flow and Wireframes

Precise visualizations of the whole product are presented through a User Flow chart (Appendix 4). In this step, connections betweens features are now linked together with details. The main purpose of this stage is to sketch out the outline of how users will navigate through the application. It is valuable not only for securing the structure but also for forming the visual framework. More functions are also planned out from the basic ones created in Card Sorting.

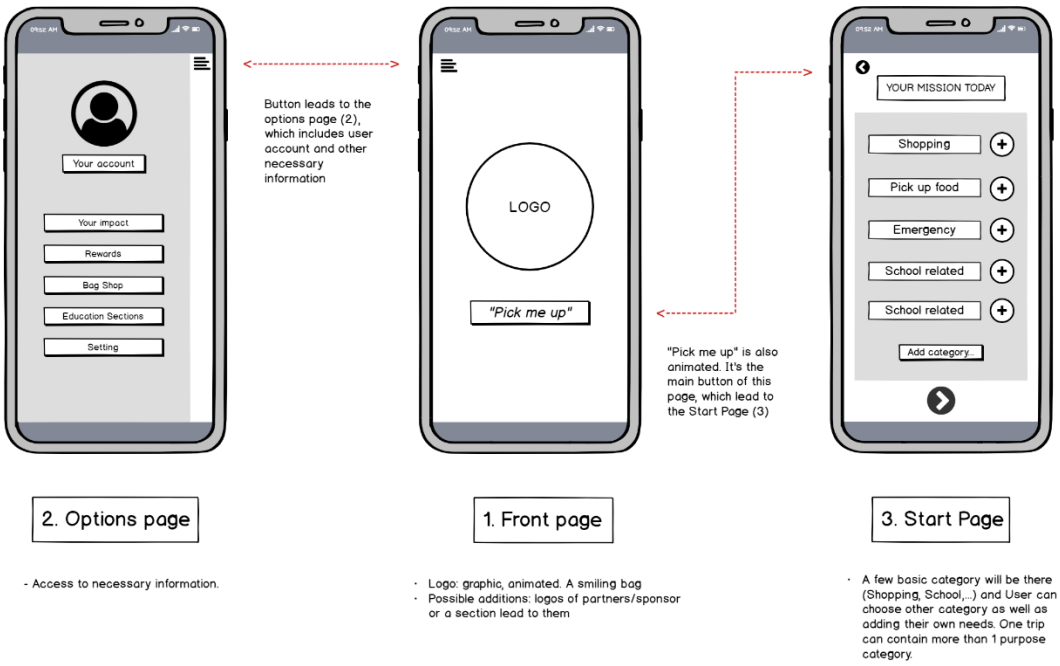

Figure 16. Wireframes for Front Page, Options and Start Page. Dang, A. 2020.

For a better vision of the product visualization, wireframes concepts were made for 6 particular pages: Front Page, Option (Menu), Start Page, Map, Station, and Impact Pages (Figure 16) (Appendix 4). Technically they are a detailed version of the same pages in the Use Flow. Yet, the closer look and specific icons shape a coherent vision for the next steps. All icons in the wireframes are plugins provided in the Balsamiq site. They are only for sketching ideas instead of representing the actual product.

5.5 UI Framework

In this stage detailed UI elements were designed, such as control buttons, icons, logo and animated features. Color theme charts and main font were also selected.

5.5.1 Alignment

Responsive design for mobile screens that are always changing sizes can be tricky. As grids can change when the screen sizes change, it is better to focus on designing a good alignment for all the content (Kennedy 2018). With a list of various devices' screens, Apple offers a tools called Auto Layout for adaptive

layout structure. It follows “constraints” that are made by designers and keeps the horizontal and vertical position in the correct ratio. Therefore, even when the size of an element changes, it would still stay in the center or any other proposition that has set. (Apple 2020.) Space awareness should also be keep in mind.

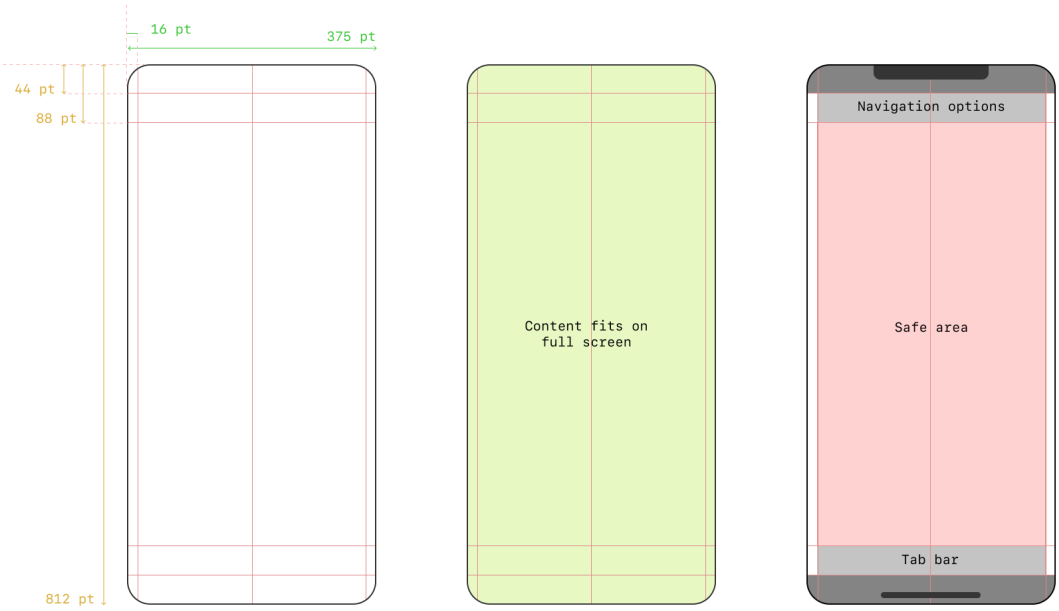

Figure 17. Iphone X’s dimension and working area (Dang 2020)

The alignment of the thesis product’s UI follows the basic recommendations for content formatting and layout from Apple (Figure 17). It includes a minimum size of 44pt x 44pt for the control buttons, in fact, all the command buttons in the round shape have that same size. Margins from both right and left size are 16pt. Navigation and tab bar space is reserved for navigation and tab buttons. The main contents never excess the safe area. The author chose iPhone X’s screen dimension as the frame for prototyping because of its popularity and adaptable orientation to other iOS devices. Landscape view is not considered for the product.

5.5.2 Logo design and color

With the goal to create a bright and vibrant color theme, lime green, cherry red and mustard yellow were chosen for the brand’s color identity. In which lime

green is the primary color, with the use of various saturation and brightness Different shades of grey are also present as neutral color balance.

Figure 18. Logo and color theme of PicBag (Dang 2020)

Aesthetic brings emotion to the user which in some cases are positive to the whole experience using the product, however, there should be a balance between aesthetic and usability in order to satisfy both the users and clients, as well as maintaining the attractive look, functional and durable.

Meanwhile, different cultures and heritages in the world have assigned different meanings into certain colors as part of their long time tradition. Hence, attempts to make a whole group of people to have the same reaction with chosen colors can be difficult (Chapman 2010). However, cognitive studies have pointed out that it is not just a single color that make up the emotions, but combinations of colors, patterns and their propositions altogether. For example, vibrant and light colors combined with rounded curves in a wide space can bring up positive feelings of energy, harmony and renewal. (Lee 2019.) Following and working

around principles of aesthetic and joy can therefore provoke visual cognition in the human brain, rather than repeatedly color bias behavior.

5.5.3 Icon Design

A great icon design converts concept clearly and provides a quick and easy to understand visual communication. It requires a careful approach from the designer, as they need to consider the existing industrial standards and their own product's overall flow. A few design principles can be applied to create a package of icons that achieve universal understanding between users. (Zhang 2020.)

Brevity, Readability and Clarity: the main target of any icon design is to communicate concepts in the simplest way possible. Common elements like navigation arrows, warning signs, menu options,…usually are presented as short and plain icons (Appendix 6). Sizes and spaces within the design are carefully taken into account as well to maintain the legibility on different devices' screens.

Figure 19. Set of icon with fixed personality (Dang 2020)

Consistency and *personality:* when belonging in the same group or family, icons should have a similar flow of harmony, including style, stroke weight, shape and

scale. Following the design of the application's logo, a set of icons were created with the same style and color (Figure 19). Together with the rest of the brand features, they create a consistency in visual flow for the application.

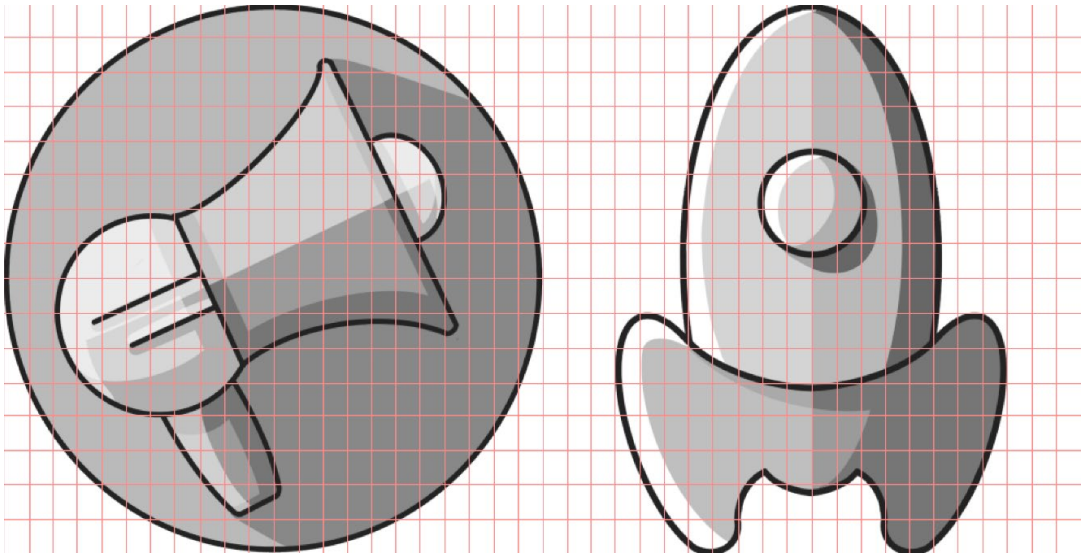

Figure 20. Consistency and alignment in icon design (Dang 2020)

Alignment: even though in most cases a fine alignment with equal numbers between space brings the best result, sometimes it is necessary to adjust them as well (Figure 20). For example, in Figure 21 the arrow needs to be moved unsymmetrical to the left a little in order to have more balance. Otherwise, a direct centered position makes a heavy impression on the right for the human eyes.

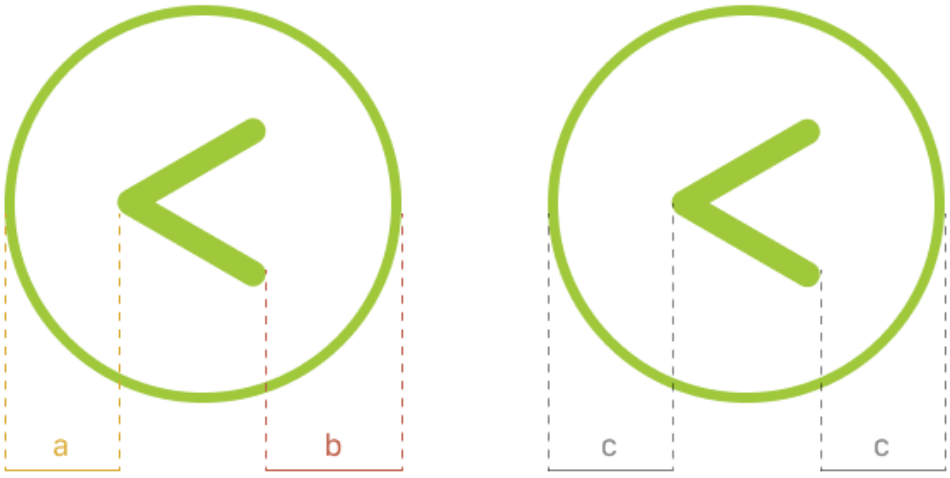

Figure 21. Exceptional adjustment in alignment to make an icon balance (Dang 2020)

5.5.4 Typography

Besides images, text is the next important element in information visualization. Words themselves are information and typography is the way to transfer them. An effective typography choice should satisfy the following factors: typefaces, text hierarchy. Their goals include making a positive impression on UI, directing users' attention to the right place, and providing smooth navigation between functions.

Typefaces contain different parts in type classification - serif, sans serif, script, monospaced, and display; type style – light, regular, italic, medium, semibold, bold (Chapman). Each part has its own uniqueness in terms of text scale, spacing, serifs volumes, leading, kerning, and tracking. They should be used carefully in different contexts. The effect of majuscule and minuscule choices in a text is significantly powerful as well. Majuscule characters require the reader to observe each individual word so it can be tiring to read too much of it. It catches the users' eyes easily so it is suitable to use for headlines or special words. Meanwhile, consistency is also an important factor to keep in mind. Text with the same priorities in different pages or frames needs to have the same sizes. (Tubik Studio 2017.)

Text hierarchy is affected by different adjustments: sizes, style, and lightness, or opacity. According to Apple's official UI guide, 11pt is a minimum size for text to manage a readable and clear view on a phone screen. However, it is most ideal to put text around 15-19pt. More spaces in general for both words and icons are also highly recommended. (Apple 2020.) Text priority can be divided into 3 groups: body text, subtitle, and title. Body text has the most space and it is crucial to make sure it has an average, readable size. Subtitles give additional information, a distinctive size and color or opacity can make it notable even when users speed reading the content. Important text such as headlines or titles should be the biggest in order to stand out yet not too big that it overrun the space. Different styles, colors, and volume of opacity is valuable in distinguishing typography hierarchy as well. (Kennedy 2020.)

The typography chosen for the product's UI was SF Mono, a default font for iOS application. Belonging to the Sans typeface family, it provides a simple and delicate impression. A non-serifs and monospace appearance makes it easy for alignment and pairing with the product's graphic style. Another reason is that the prototype is, from the beginning, intended to design for iOS platform and Apple devices. Therefore, it uses an exclusive font provided by Apple directly. For the logo, Righteous font was used. The name "PicBag" goes well with another monospace with thick weight and squared corner.

5.6 Prototyping

Prototypes were being built simultaneously throughout the implementation making process. Yet there are two of them that have major changes affecting the final product. The first prototype was built with Adobe XD (Figure 22) (Appendix 5), which went really well when it only had wireframes instead of actual UI elements. Problems occurred when it was time to imply map function. Adobe XD has limited resources and tools to simulate a map flow. Alternative software was considered, including Figma, Sketch, UXPin, and Balsamiq. Figma was chosen as it provides suitable functions to implement the prototype. In the end, results proved that it was the right choice and the making process and working flow were even better than the first choice.

Some questions arose related to the user flow when using the interactive map: What is the way for the user to unlock/ recognize the station once they get there after using the map? QR code was the first and foremost solution. Yet, it links strongly to the development stage. A solution of using motion design was used to replace the lack of coding and simulate the process of scanning a QR code. It has succeeded in maintaining a smooth user flow for the application.

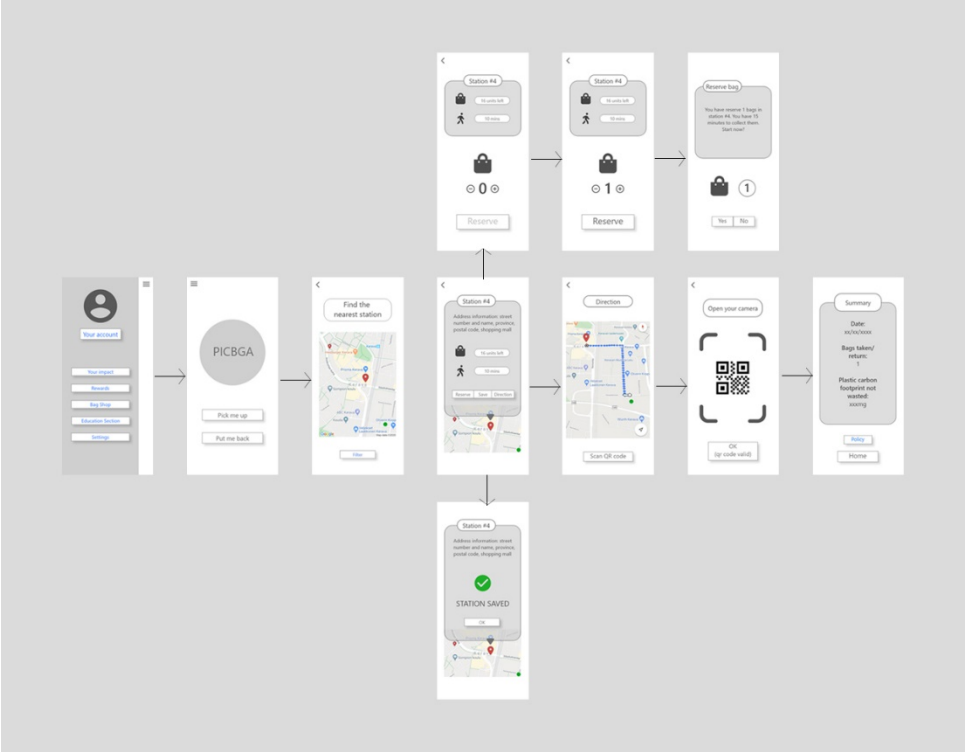

Figure 22. First wireframe prototype made in Adobe XD (Dang 2020)

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5.7 Final Product and User Testing

A walk-through video of the prototype is available here: https://youtu.be/pFZ_u6G02Oc

The final product is an interactive prototype with various working functions inside the application. Essential features were made based on the first wireframe one. New polished UI elements such as icons, logos, and buttons were added. Some particular changes in the functions were made: some frames have animated elements to simulate the working flow of a working application, as well as to demonstrate the user journey related to map function better. “Save station” button was eliminated according to unpractical usage feedback from the first user testing. “Share” button is available for sharing a user's data record. For example, a user can share how many plastic bags he has not brought when using the application.

Due to technical issues in importing map API in a prototype, the author chose to use Google Map Styling Wizard for creating a map style that fits with the

product's main visual theme. Detailed adjustments with color and shape were made in the Google Map site with a custom JSON (Appendix 8). The JSON code is only available for testing and viewing the prototype. On the map's visual: main colors are lime green and cherry red, which is the same with the application's UI style, with a touch of retro feeling (Figure 23). Saturation and contrast were decreased for a balance and soft impression. Landmarks names and labels are reduced to the minimum, with only important components like bus and train stations are shown.

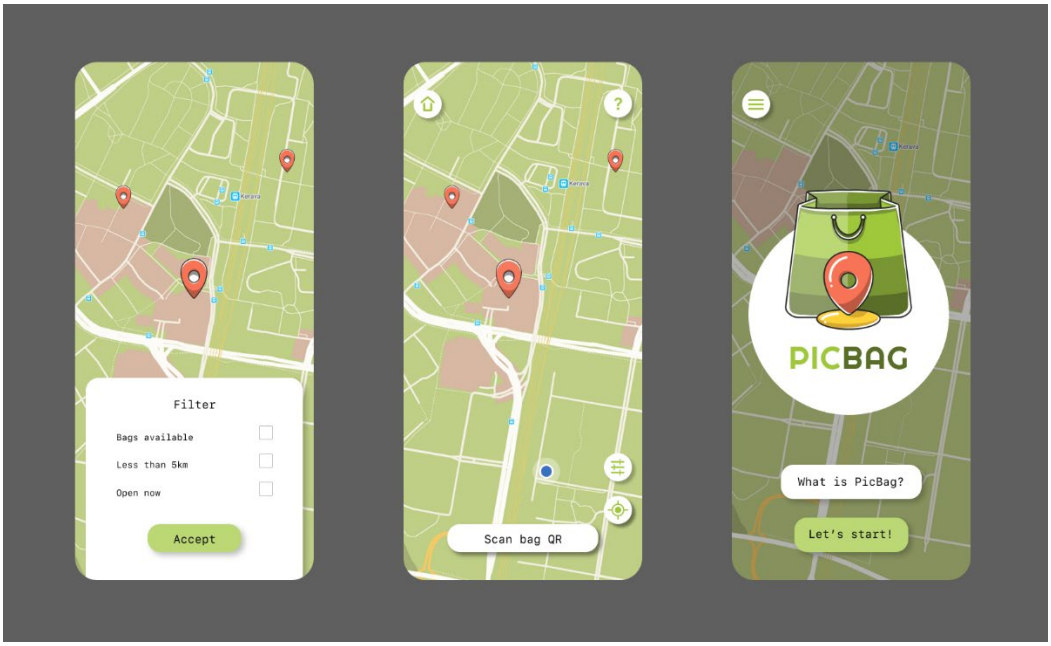


Figure 23. Customized map used in final product (Dang 2020)

The same participants who did the user interview for making personas receive user testing questions for the second prototype. Difficulties occurred at the final user testing: as the test participants live in different regions and countries, their reaction to the map function is not the same. Especially when people can not see the real streets and follow the routes in real lifetime, it is unpredictable to evaluate the success of the interactive map itself. However, the test results have justified a few things: most participants reported that the map UI style has fit the rest of the application's visual theme nicely, as well as the legibility of station locations thanks to the motion design.

The visual design and layout, on the other hand, are not easy to evaluate as users' feedbacks are influenced by personal preferences. Overall, users rated it above average in the sense of authentic and main color choice were favored by most users. One particular opinion gave negative feedback on the lime green and one stated they personally dislike the comic-inspired UI style. Meanwhile, the logo design received special endorsements from 2 people and is rated highly by the rest.

6 CONCLUSION

Both the researching and implementation parts have achieved a certain kind of expected outcomes, although there are several aspects that can be improved.

On the side of UI and UX design, different methods were applied as planned, with various failed attempts and recovers. Interaction design principles were taken into account when organizing interactive features, as well as motion design for simple animation. Brand identity design including logo and icon design with consistency in style and color choice saw a positive outcome. Different courses on visualization, concept art and UI/UX design during the study have prepared greatly for the author to take on those tasks.

Results from the final product's User Testing showed that the implementation part has succeeded in creating maps functions that work well with the overall application's usability. However, one of the primary goals of the thesis was to design a whole interactive map visualization. In the process of researching the development part for building maps in mobile, the author realized that it is impossible to handle the map alone. It would need a huge database and navigation system. Instead, useful information on how to create and apply SDK and API in iOS system was found. It would be valuable when working in a functional application, as well as convenient in communicating with the development team.

Some issues also forced the author to look and study further in unexpected areas. One of them is the learning of prototyping tools and software. Several software such as Adobe XD, Balsamiq and Figma were tested. Reviews and evaluation on the others were analysed as well. Another pleasant surprise in

researching is the climate problems concerning plastic. Specialized articles on environmental problems have broadened the author’s understanding and mindset of the topic.

Overall, even though the research on cognition studies could be more specialized and focused, it provided enough information to understand the system and its connections with interactive maps. The implementation product also applied the theory concluded during the researching part, as well as lessons from classes during the study at school.

REFERENCES

Apple Developer. 2020. IOS Human Interface Guidelines. Available at: https://developer.apple.com/design/human-interface-guidelines/ios/overview/themes/ [Accessed: March 2020].

Alan Cooper & Robert Reimann. 2003. About Face 2.0: The Essentials of Interaction Design. New Jersey: John Wiley & Sons, Inc.

Cameron Chapman. Unknown date. Understanding the Nuances of Typeface Classification. Available at: https://www.toptal.com/designers/typography/typeface-classification [Accessed: 1 May, 2020].

Cady Wachsman. March 2017. Uber Navigation. Available at: https://medium.com/uber-design/uber-navigation-f662e7611f3 [Accessed: 20 April, 2020)

Carl Moreland and David Bannister, editors. 1983. Antique Maps. New York: Phaidon Press.

Christopher Joyce. July 2019. Plastic Has A Big Carbon Footprint — But That Isn't The Whole Story. Available at: https://www.npr.org/2019/07/09/735848489/plastic-has-a-big-carbon-footprint-but-that-isnt-the-whole-story [Accessed: 6 May 2020].

Daniel M. Brown. 2010. Communicating Design: Developing Web Site Documentation for Design and Planning. San Francisco: New Riders Publishing.

Donald A. Norman. 2002. The Design of Everyday Things. New York: Basic Books.

D. F. Merriam. 1996. Kansas 19th century geologic maps. Kansas Academy of Science, Transactions 99, p. 95-114. Available at: https://www.jstor.org/stable/3627983?seq=1 [Accessed: 12 April, 2020]

Edward C. Tolman. 1948. Cognitive maps in rats and men. Psychological Review, 55(4), 189–208.

Edward R. Tufte. 1983. The Visual Display of Quantitative Information. United States: Graphics Press.

Helena Zhang. January, 2020. 7 Principles of Icon Design. Available at: https://uxdesign.cc/7-principles-of-icon-design-e7187539e4a2 [Accessed: 1 May, 2020]

Eric Johnson and Nicoletta Adamo-Villani. 2010. A Study of the Effects of Immersion on Short-term Spatial Memory. World Academy of Science, Engineering and Technology 47. 71: 582-587.

Erik D. Kennedy. December 2018. Why Beginning Designers Don't Need to Learn Grids, Type Scales, or Color Theory. Available at: https://learnui.design/blog/why-beginning-designers-dont-need-grids-type-scales-color-theory.html [Accessed: 6 May, 2020]

Hannah Ritchie and Max Roser. September 2018. Plastic Pollution. Available at: https://ourworldindata.org/plastic-pollution [Accessed: 3 May, 2020]

Ingrid Fetell Lee. 2019. Joyful: The Surprising Power of Ordinary Things to Create Extraordinary Happiness. New York: Little, Brown Spark.

James S. Aber. 2008. Brief History of Maps and Cartography. Available at: http://academic.emporia.edu/aberjame/map/h_map/h_map.htm [Accessed: 24 April, 2020]

Jenifer Tidwell. 2010. Designing Interfaces: Patterns for Effective Interaction Design. California: O'Reilly Media.

Jitesh Rajani. August, 2018. User Journeys and User Flows, Understanding the Difference. Available at: https://blog.prototypr.io/user-journeys-and-user-flows-understanding-the-difference-87c0f17d3c5f

Kate Bratskeir. January 2019. How To Recycle Plastic Bags The Right Way. HuffPost Impact. Available at: https://www.huffpost.com/entry/how-to-recycle-plastic-bags_n_5c4b80f8e4b0e1872d43b9a4?fbclid=IwAR2Q-pG50M9sZT5j7m1ujhixtxtJDBERVeB9f--QuJe9WtUTOTIvuIwhVFo [Accessed: 12 May, 2020]

Kevin Silver. July, 2003. What Puts the Design in Interaction Design. Available at: https://www.uxmatters.com/mt/archives/2007/07/what-puts-the-design-in-interaction-design.php [Accessed: 7 April, 2020]

Laura Parker. November 2018. China's ban on trash imports shifts waste crisis to Southeast Asia. National Geographic. Available at: https://www.nationalgeographic.com/environment/2018/11/china-ban-plastic-trash-imports-shifts-waste-crisis-southeast-asia-malaysia/?fbclid=IwAR3dB8zQToSVau1kcFEXcC4D0c8Kubj_HpHohzibXGJ8ksfpZ5UGO9Afqps [Accessed: 5 May, 2020]

Lindström Group. 2020. Returnable shopping bags reduce plastic waste. Available at: https://lindstromgroup.com/services/returnable-shopping-bags/ [Accessed: 12 May, 2020]

Maneesh Agrawala. December 2001. Visualizing route maps. Ph.D. Dissertation, Stanford University. Available at: https://graphics.stanford.edu/papers/maneesh_thesis/ [Accessed: February, 2020]

Menno-Jan Kraak. 2014. Mapping time: illustrated by Minard's map of Napoleon's Russian Campaign of 1812. California: Esri Press.

Muovipussiton Kerava – Plastic Free Kerava. 2020. [website]. Available at: https://www.muovipussitonkerava.fi/ [Accessed: 12 May, 2020]

Robert E. Roth, 2013. Interactive Maps: What we know and what we need to know. Journal of Spatial Information Science 6:59-115. Available at: https://www.researchgate.net/publication/271078641_Interactive_Maps_What_we_know_and_what_we_need_to_know [Accessed: 14 April, 2020]

Rudolph P. Darken & Barry Peterson. 2001. Spatial Orientation, Wayfinding, and Representation. Naval Postgraduate School. Available at: https://www.researchgate.net/publication/2557944_Spatial_Orientation_Wayfinding_and_Representation [Accessed: 14 March, 2020]

Tubik Studio. August 2017. Typography in UI: Guide for Beginners. Available at: https://uxplanet.org/typography-in-ui-guide-for-beginners-7ee9bdbc4833 [Accessed: 4 May, 2020]

Susan M. Weinschenk. 2015. 100 More Things Every Designer Needs to Know about People. San Francisco: New Riders Publishing.

Simon Pan. 2012. Uber Magic 2.0: Perfecting the pickup for the Rider app redesign. Available at: http://simonpan.com/work/uber/ [Accessed: 5 January, 2020]

University of California - Santa Barbara. April 2019. Plastic's carbon footprint. ScienceDaily. Available at: https://www.sciencedaily.com/releases/2019/04/190415144004.htm [Accessed: 5 May, 2020]

UXPin. 2015. Consistency in UI Design: Creativity Without Confusion. Ebook. Available at: https://www.uxpin.com/studio/ebooks/consistency-ui-design-creativity/ [Accessed: 21 March, 2020]

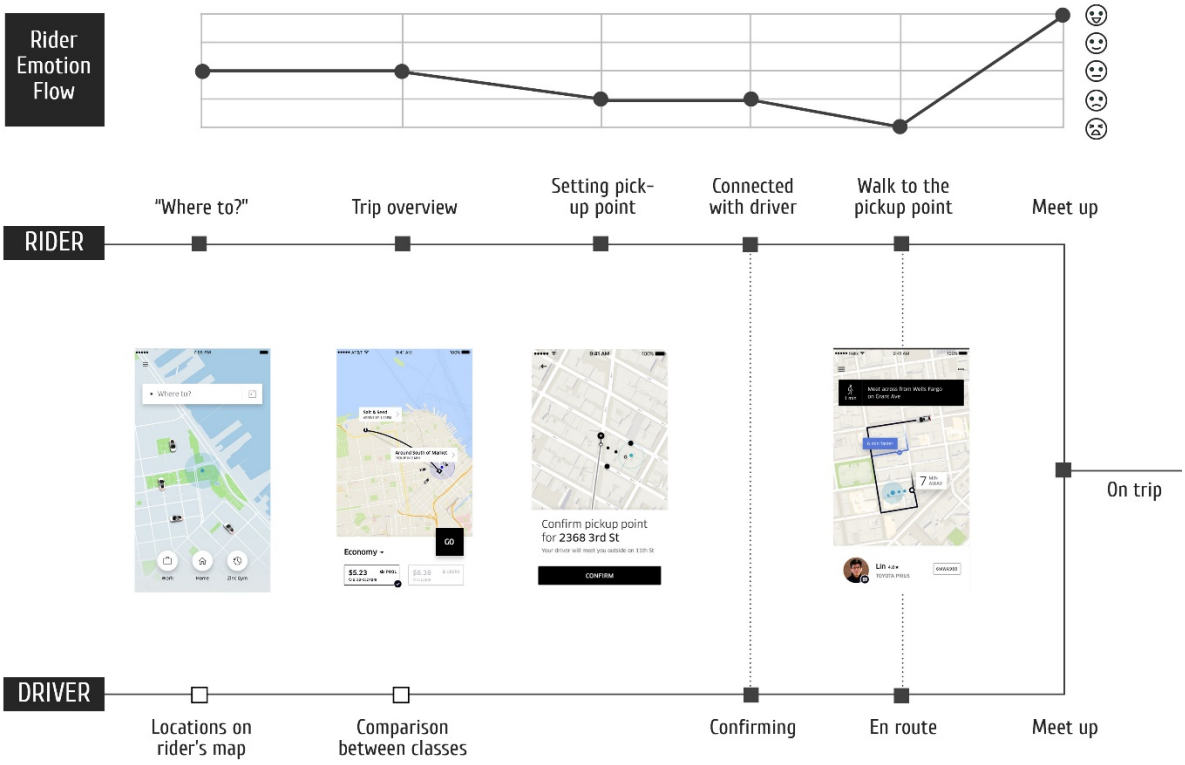
Waste (England and Wales) Regulations. 2011. Guidance on applying the Waste Hierarchy. Department for Environment, Food and Rural Affair. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69403/pb13530-waste-hierarchy-guidance.pdf [Accessed: 5 May, 2020]

Yle Newspaper. September 2019. Finland slow to give up plastic bag habit. Available at: https://yle.fi/uutiset/osasto/news/finland_slow_to_give_up_plastic_bag_habit/10972841?fbclid=IwAR2V9PuekVs6XHngMoJdUnEVK4aXjlvNW7vkwkmOCaHsioCq07Jxu5B8Avg [Accessed: 5 May, 2020]

Yle Newspaper. December 2019. Plastic recycling in big cities doubles in 2019. Available at: https://yle.fi/uutiset/osasto/news/plastic_recycling_in_big_cities_doubles_in_2019/11135850 [Accessed: 5 May, 2020]

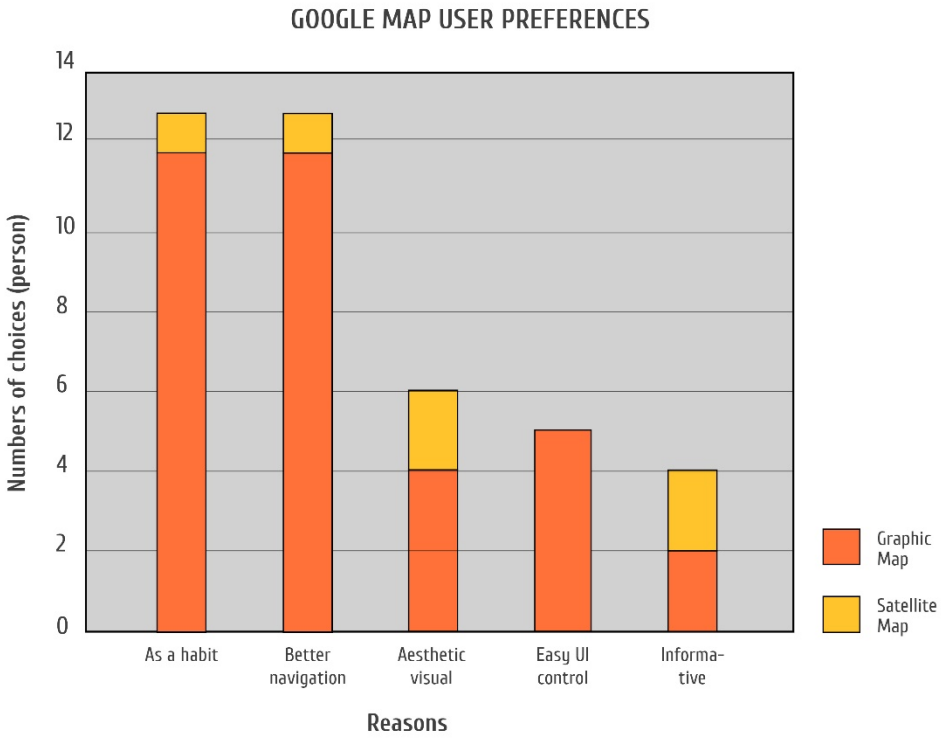
LISTS OF FIGURES

Appendix 1

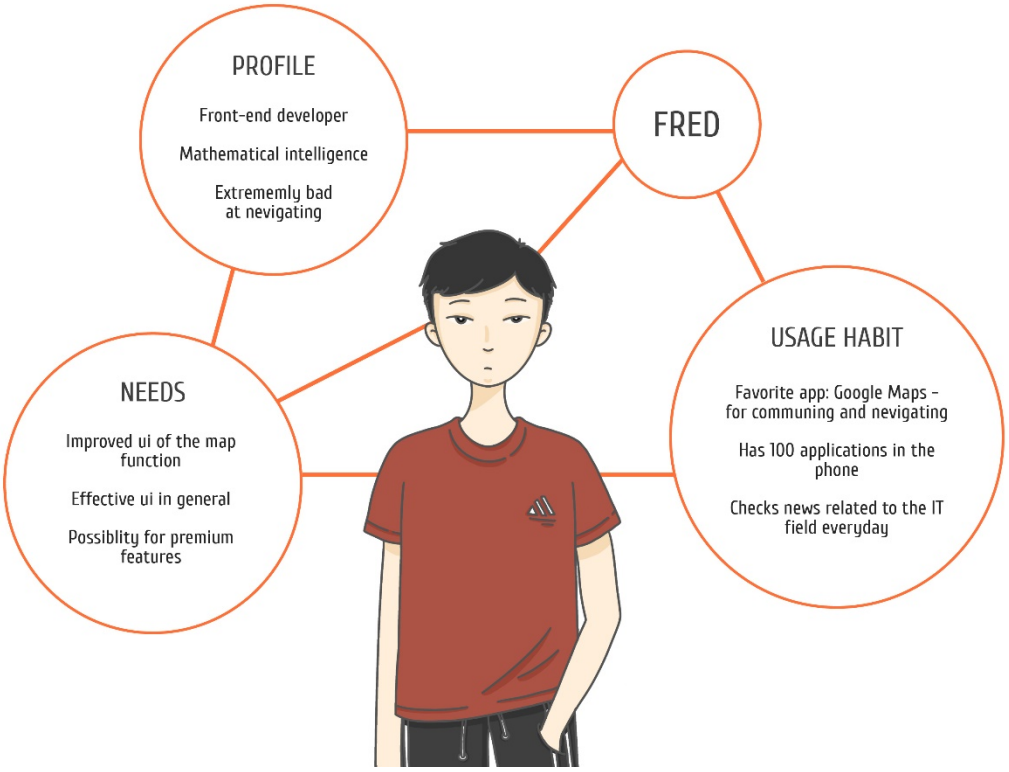


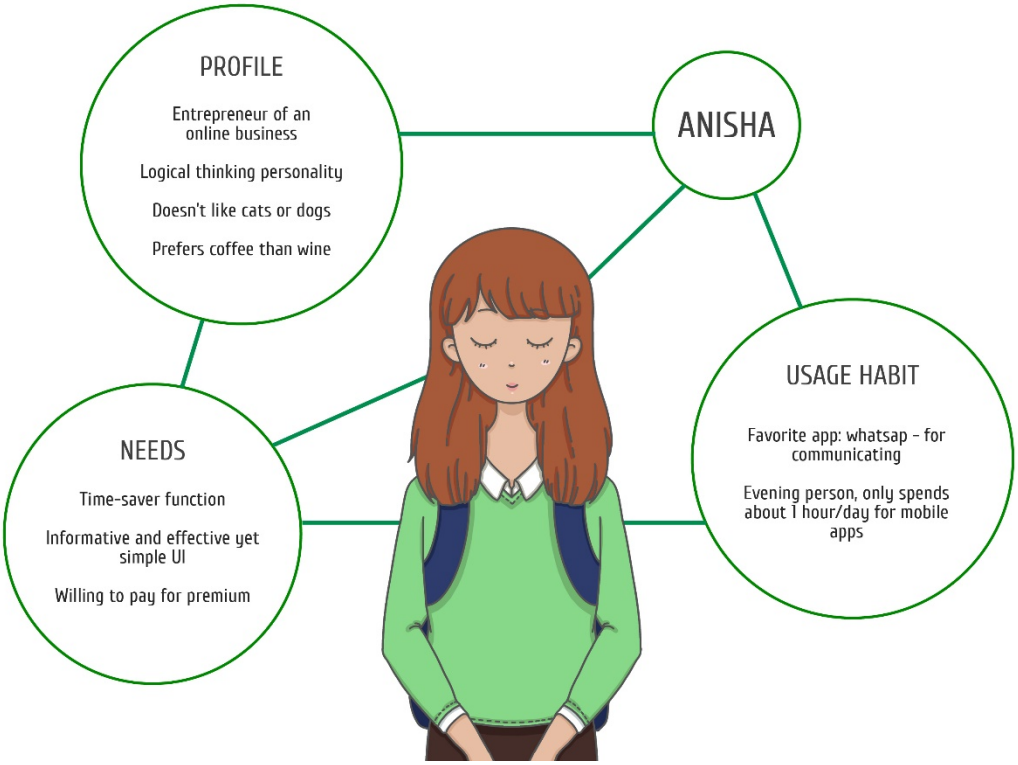
Uber's Map Design and User Flow

Appendix 2

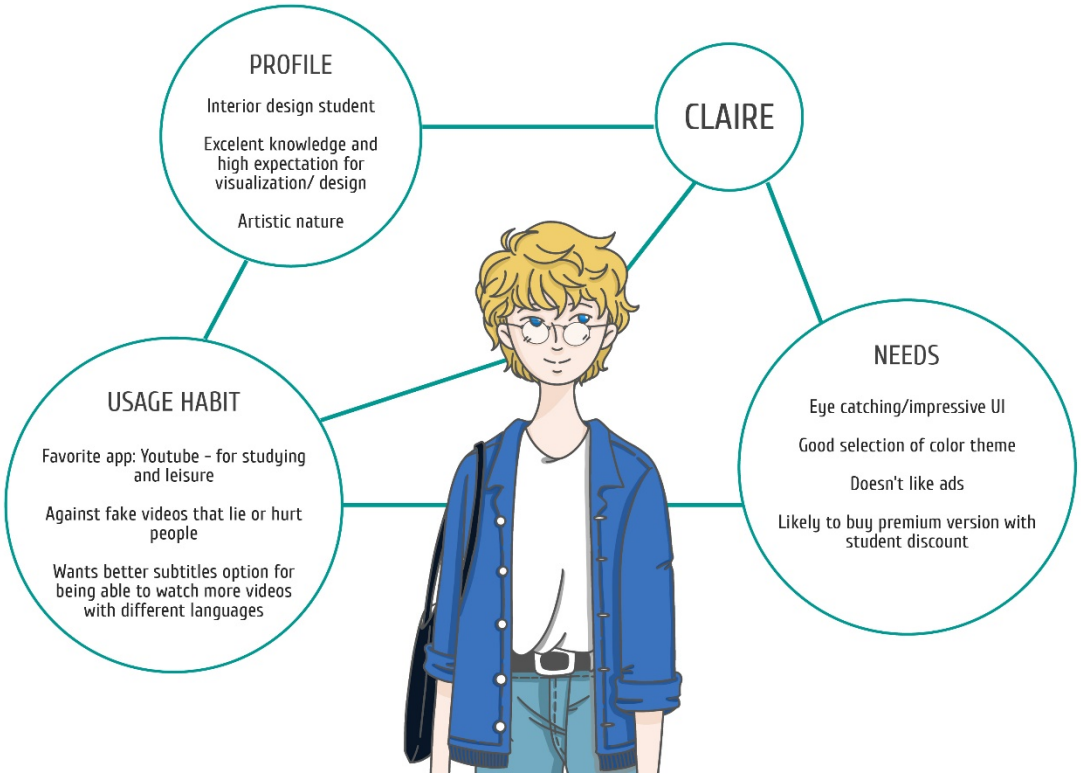


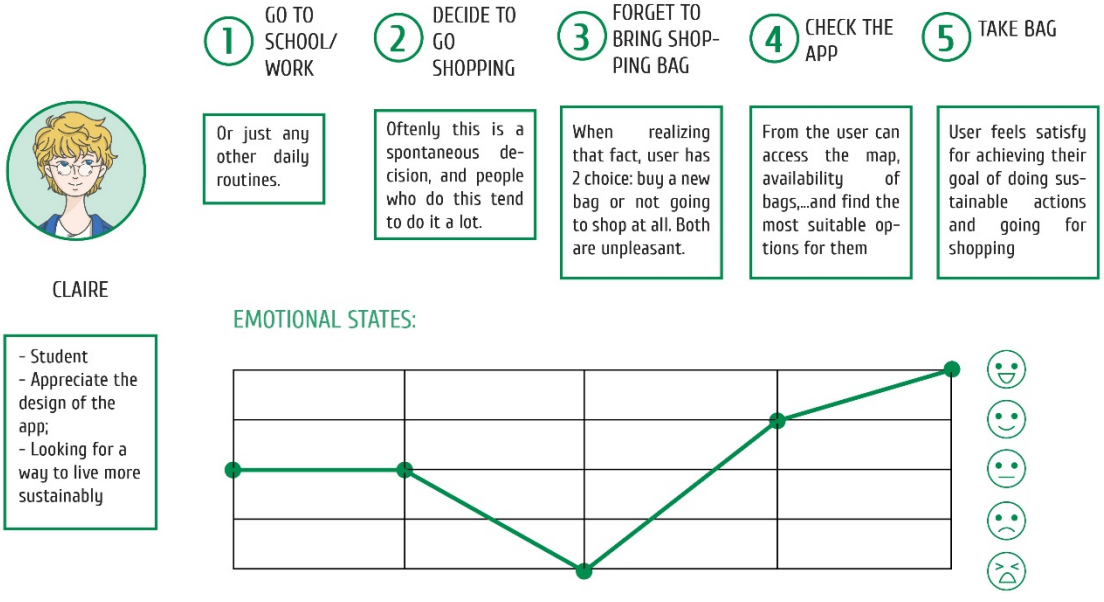
Google Map User Preferences between Graphic and Satellite Map chart


PROFILE
Front-end developer
Mathematical intelligence
Extrememly bad at nevigating
FRED
NEEDS
Improved ui of the map function
Effective ui in general
Possiblity for premium features
USAGE HABIT
Favorite app: Google Maps - for communing and nevigating
Has 100 applications in the phone
Checks news related to the IT field everyday

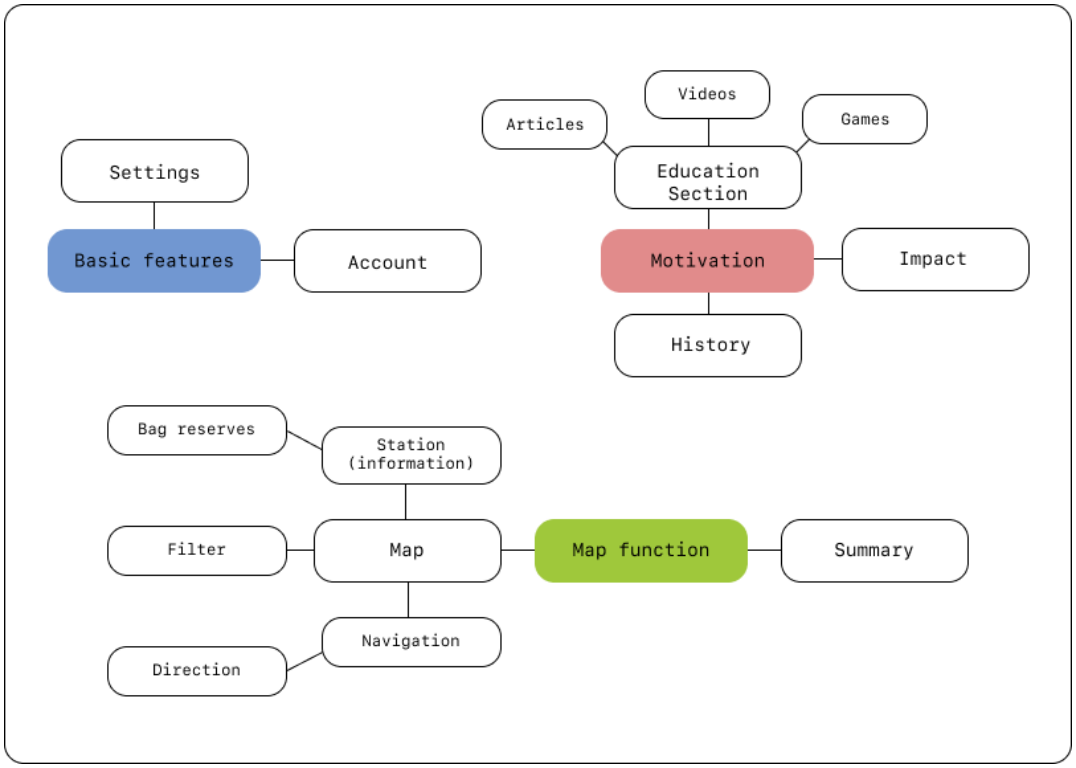

PROFILE
Entrepreneur of an online business
Logical thinking personality
Doesn't like cats or dogs
Prefers coffee than wine
ANISHA
NEEDS
Time-saver function
Informative and effective yet simple UI
Willing to pay for premium
USAGE HABIT
Favorite app: whatsap - for communicating
Evening person, only spends about 1 hour/day for mobile apps

Personas



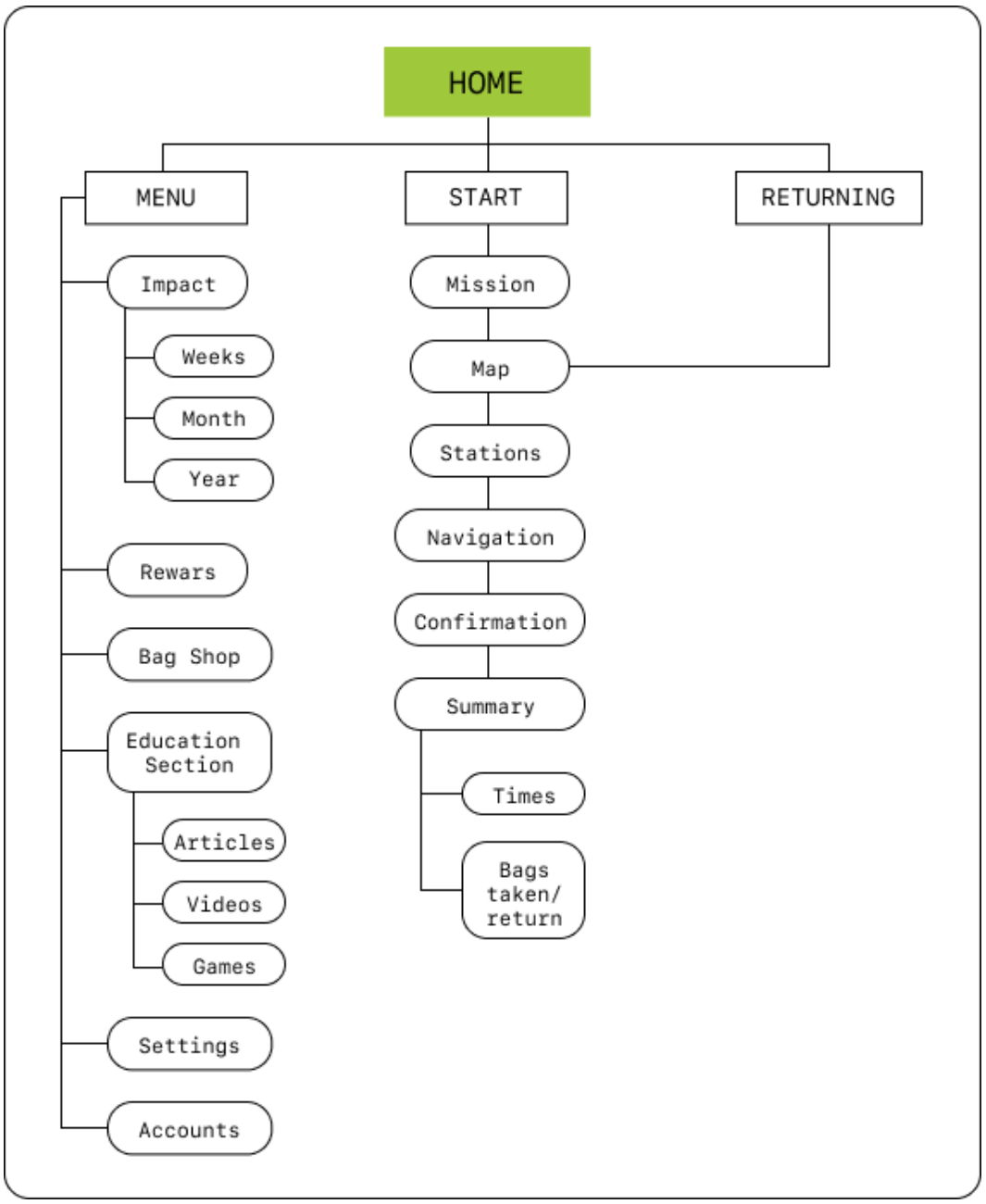


Personas and User Journey Map



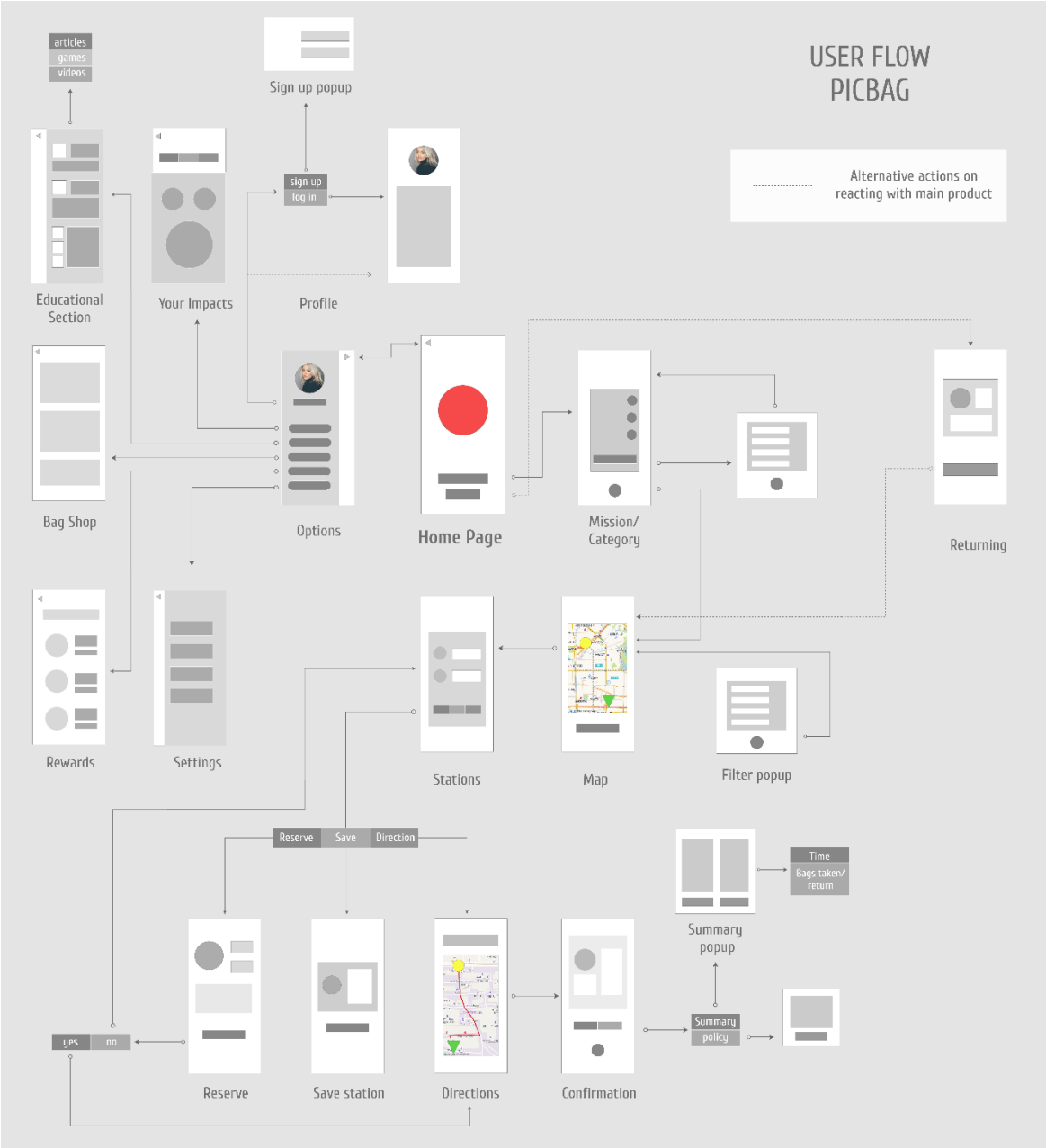
Information Architecture:

Card Sorting chart



Information Architecture:

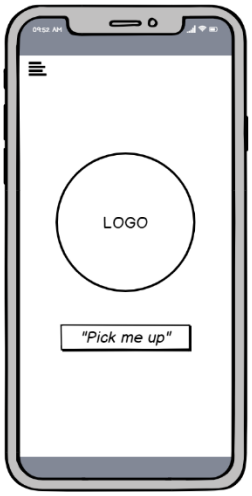
Sitemap



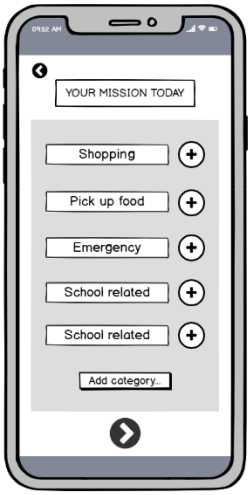
Information Architecture:

User Flow

Button leads to the options page (2), which includes user account and other necessary information



"Pick me up" is also animated. It's the main button of this page, which lead to the Start Page (3)



2. Options page

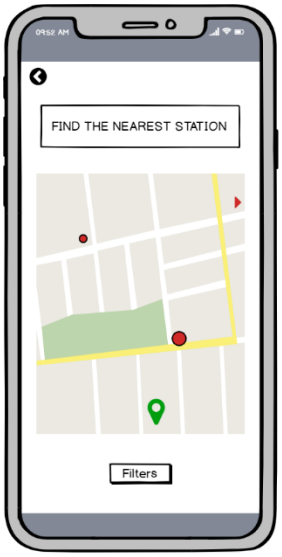
- Access to necessary information.

1. Front page

- Logo: graphic, animated. A smiling bag
- Possible additions: logos of partners/sponsor or a section lead to them

3. Start Page

- A few basic category will be there (Shopping, School,...) and User can choose other category as well as adding their own needs. One trip can contain more than 1 purpose category.



Clicking on each station will lead to its information section

4. Map page

- The map will be interactive and a strong focus will be paid to its visualization and design

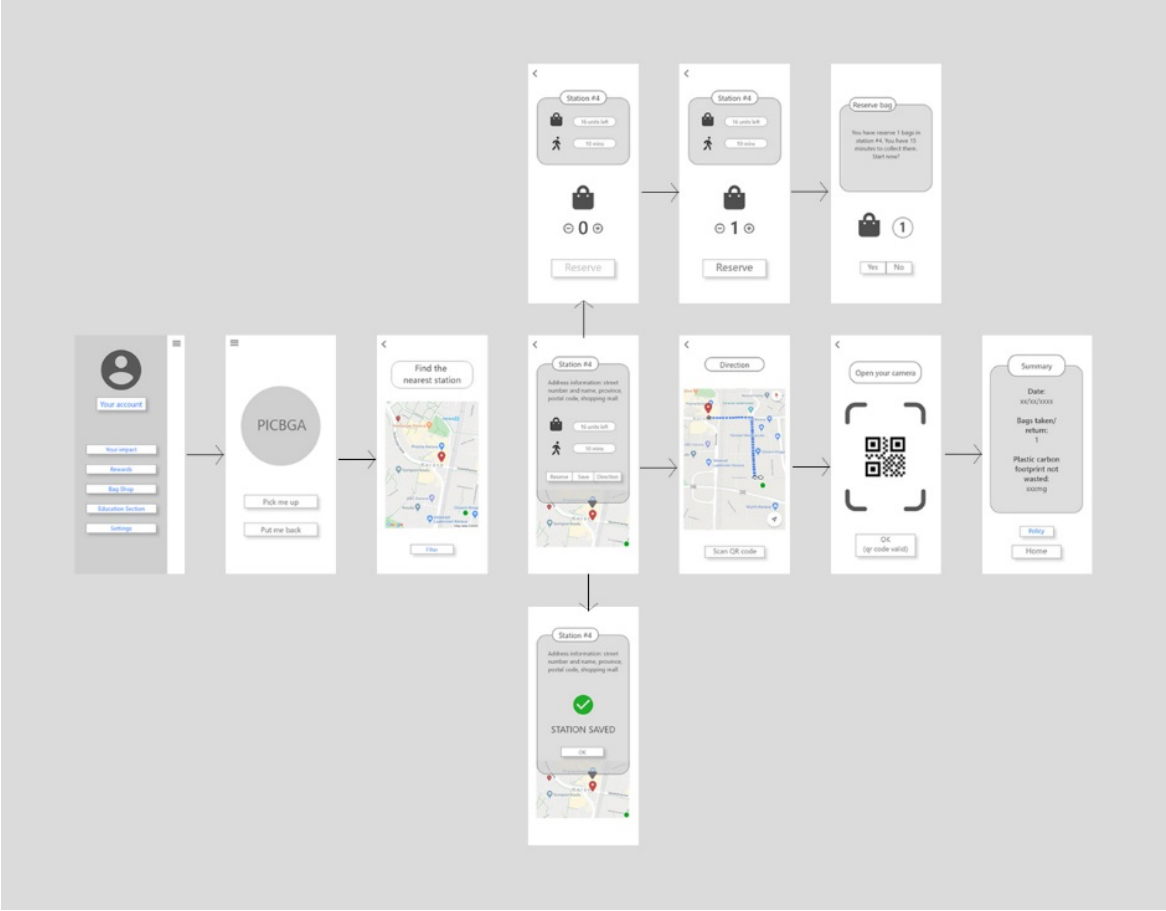
5. Station page

6. Impact page

- This page is from the (2) Options Page.
- Source on the CO2 amount: https://stopplastics.ca/carbon-footprint-plastic

Information Architecture:

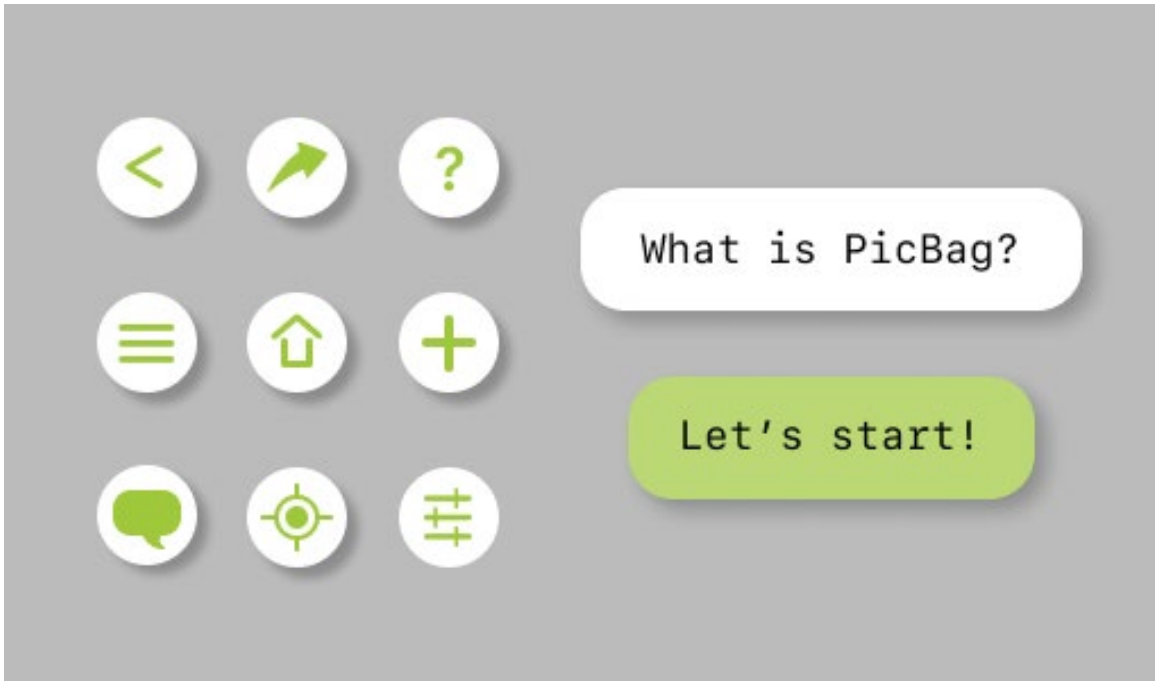
Wireframes



Prototype Version 1

UI Framework:

Logo design and color theme

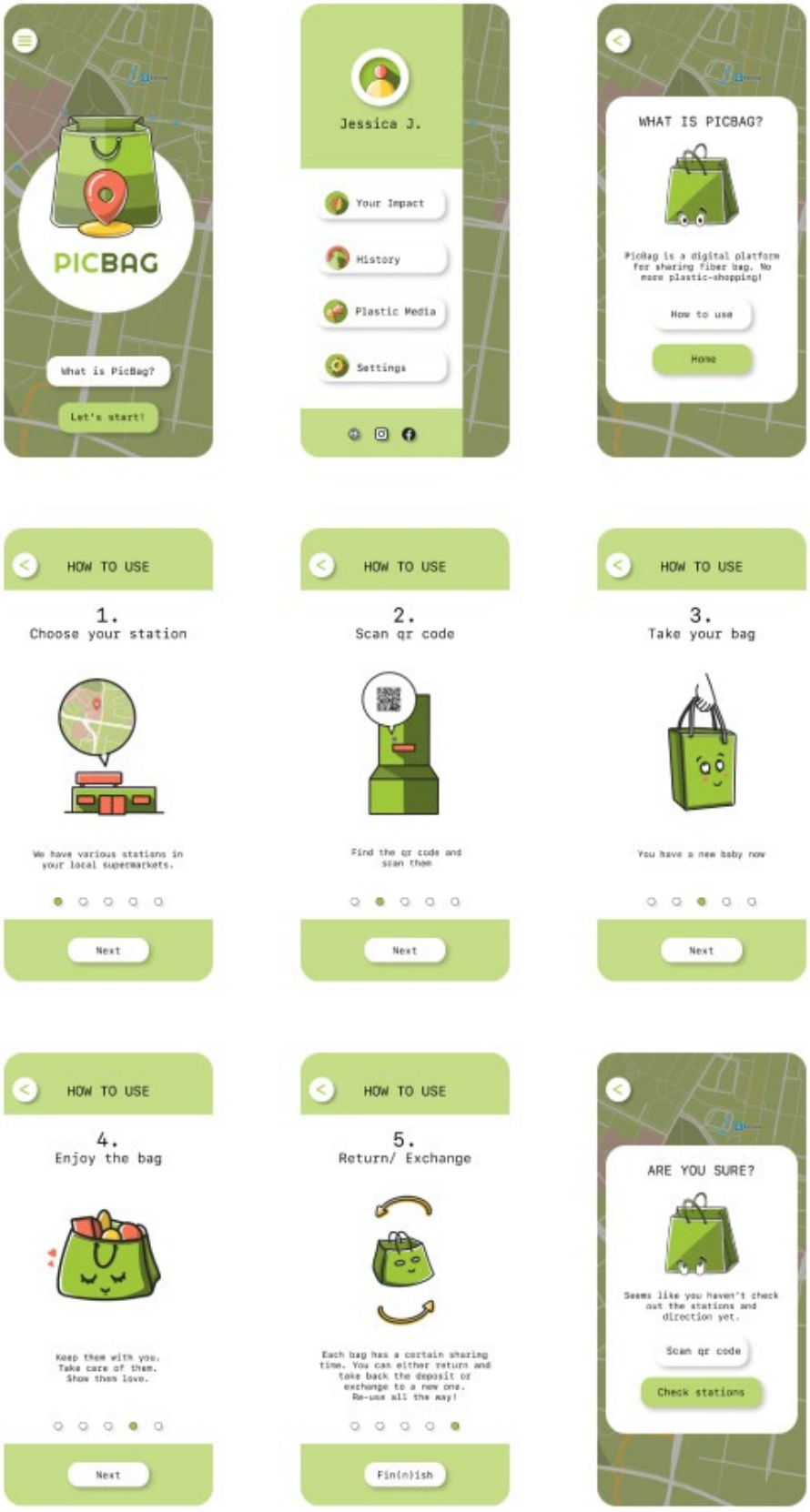


UI Framework:

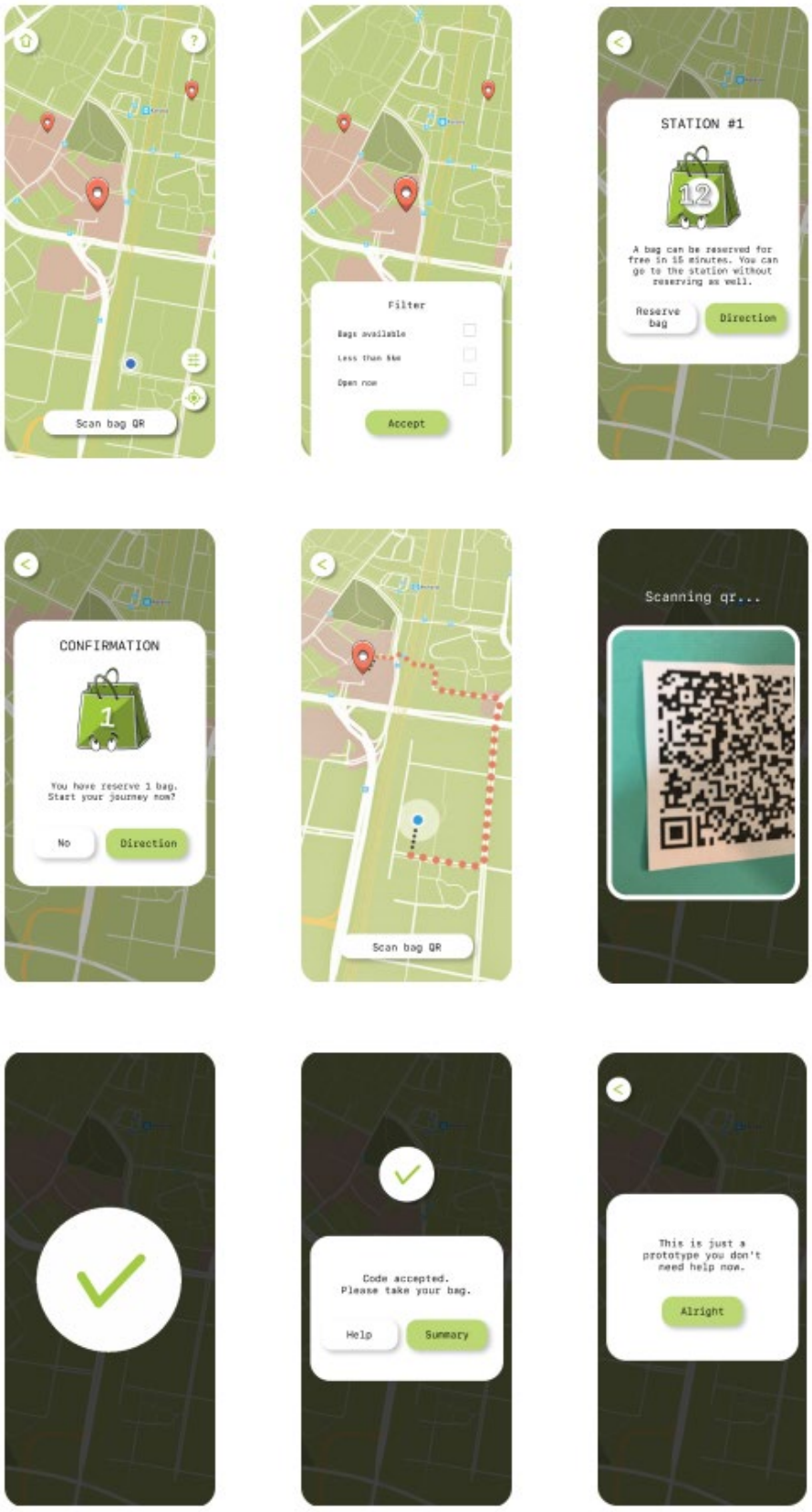
Control buttons

UI Framework:

Icon set

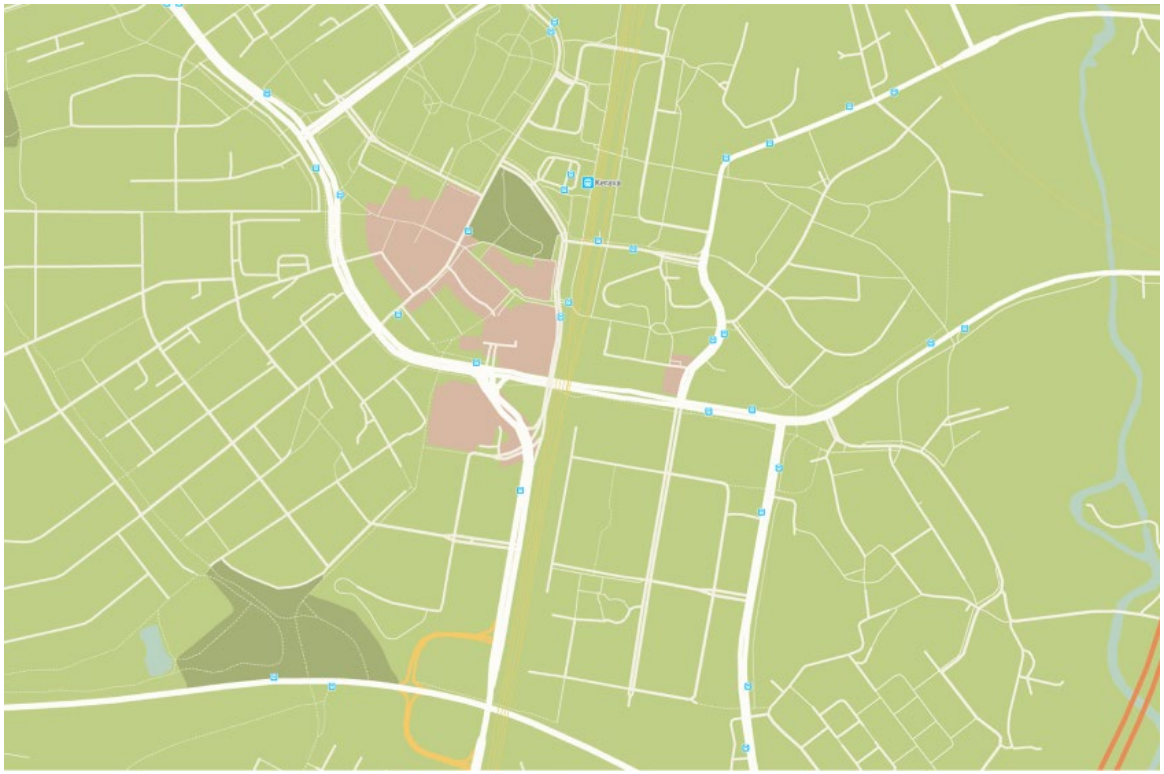


Interactive prototype frames



Interactive prototype frames

Interactive prototype frames



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Customized map JSON

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Customized map JSON

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Customized map JSON

PicBag User Testing

Hi, this is an User Testing question list for a mobile application PicBag.
Please try the prototype before checking the questions.

Instruction:
So the app, PicBag, provides a non-plastic bag sharing platform. Your task is to rent out a bag. You finished your task when a summary confirms that you have rent 1 bag. More explanation and information are inside. There is no time limit, feel free to explore the app. And have fun.
*and also please be patient with it, some animation features take time before being active.
Link to the prototype: https://www.figma.com/proto/9BUiCW77LTQYCXelZMdjRV/PicBag?node-id=4%3A14&viewport=2285%2C246%2C0.5&scaling=scale-down (please do it on a laptop it's not compatible for mobile screen yet.)

*This is a material for a bachelor thesis and every answer remains anonymous. Anyway if you are here it means you already did the survey before. A big thank you <3
*Required

1. Where do you live? (City) *

2. Your age? *

3. How often do you buy a plastic or paper bag when checking out at the supermarket? *

Mark only one oval.

- ◯ Everytime I go shopping
- ◯ Only sometimes, when necessary
- ◯ Never, I carry my own bags

4. Do you consider yourself actively practicing sustainable living? *

Sustainable living can be briefly explained as various actions and changes in daily-life that decrease the use of plastic, electricity, shopping, trash and increase the use of natural resources.

Mark only one oval.

- ◯ I'm an expert
- ◯ I do as much as I can
- ◯ I do have some changes but I want to do more
- ◯ Not really

5. What have prevent you from doing so? *

For example: time, many, available tools, guidance, I just don't want to.

Prototype User Testing

Please make sure you tested the prototype before answering.

6. How easy was it to navigate through the app? *

(Did you success at what you wanted to do: finished the task, looking for a certain section, going back to the home screen...)

Mark only one oval.

	1	2	3	4	5	
Difficult	◯	◯	◯	◯	◯	Easy

7. How did you like the design and layout? *

Mark only one oval.

	1	2	3	4	5	
Not so much	◯	◯	◯	◯	◯	Very much

8. How would you rate the map visual design? *

Mark only one oval.

	1	2	3	4	5	
Ugly	◯	◯	◯	◯	◯	Beautiful

9. Was the station location easy to find on the map? *

Mark only one oval.

	1	2	3	4	5	
No	◯	◯	◯	◯	◯	Yes

10. What did you like the most about the app? *

For example: the idea/concept, the design, the easy functions, the animation, the logo, the color, the font, everything,...

11. What did you like the least? *

For example: the idea/concept, the design, the easy functions, the animation, the logo, the color, the font, everything,...

12. Is there anything that cause you frustration? *

For example: a certain button, can't find something, something's ugly,...

13. Did you check the "How to use" feature? *

Mark only one oval.

- ◯ Yes
- ◯ No

14. Why not?

For example: I already know how to use it, I didn't see it, didn't want to,...

15. How useful is the "How to use" section?

Mark only one oval.

	1	2	3	4	5	
Not so much	◯	◯	◯	◯	◯	The user needs it to understand

16. Did you check the "Reserve bag" feature? *

Mark only one oval.

- ◯ Yes
- ◯ No

17. Why not?

For example: I didn't see it, didn't want to,...

_____

_____

_____

_____

_____

18. Did you check the "Plastic Media" feature? *

Mark only one oval.

- ◯ Yes
- ◯ No

19. Why not?

For example: I didn't see it, didn't want to, I'm not interested,...

20. How likely would you download this app if it's real? *

Mark only one oval.

	1	2	3	4	5	
Not much	◯	◯	◯	◯	◯	Very much

21. Would you recommend it to your friends/family? *

Mark only one oval.

	1	2	3	4	5	
No	◯	◯	◯	◯	◯	Yes

22. Can you think of any other digital product that resemble this one? *

23. Is there anything you want to improve/add in the app? *

if not, write no

Finish

Thank you and have a nice day
-An

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Walk-through video of the final product:

https://youtu.be/pFZ_u6G02Oc