



UNIVERSITY OF GOTHENBURG



An evaluation of the effectiveness of design principles in a mobile application

Bachelor of Science Thesis in the Software Engineering & Management

DANIAL HOSSEINI
SEBASTIAN POTTER

University of Gothenburg
Chalmers University of Technology
Department of Computer Science and Engineering
Göteborg, Sweden, June 2015

The Author grants to Chalmers University of Technology and University of Gothenburg the non-exclusive right to publish the Work electronically and in a non-commercial purpose make it accessible on the Internet.

The Author warrants that he/she is the author to the Work, and warrants that the Work does not contain text, pictures or other material that violates copyright law.

The Author shall, when transferring the rights of the Work to a third party (for example a publisher or a company), acknowledge the third party about this agreement. If the Author has signed a copyright agreement with a third party regarding the Work, the Author warrants hereby that he/she has obtained any necessary permission from this third party to let Chalmers University of Technology and University of Gothenburg store the Work electronically and make it accessible on the Internet.

An evaluation of the effectiveness of design principles in a mobile application

Danial Hosseini
Sebastian Potter

© Danial Hosseini, June 2015.

© Sebastian Potter, June 2015.]

Supervisor: Riccardo Scandariato, Software Engineering Division

Examiner: Jan-Philipp Steghöfer, Department of Computer Science and Engineering

University of Gothenburg
Chalmers University of Technology
Department of Computer Science and Engineering
SE-412 96 Göteborg
Sweden
Telephone + 46 (0)31-772 1000

Cover picture: <http://www.shutterstock.com/s/%22user+centered+design%22/search.html>

Department of Computer Science and Engineering
Göteborg, Sweden June 2015

Abstract—the development of mobile application for smartphones has increased in the past periods, mobile phones have become an essential part of our contemporary life and helps us with our day-to-day tasks. Developing mobile application has shown to be time consuming and challenging, developers are struggling to overcome performance and interface issues. The purpose of this research were to assess what design principles contributes to a good user experience on mobile devices. To accomplish this, a mobile front end for an online search system for rental apartments with the importance of considering design principles and user-centered design was developed. With the help of interviews and feedback we optimized and improved the application in order to achieve a good user experience. The developed product showed to perform well, provided the core functionality and followed specific design principles that was needed for this research. We identified certain design principles that contributes towards a good user experience on mobile devices. However, the application have areas it can improve in such as performance and indicators, these could later be improved in a future study. The user experience showed to be more enjoyable on the mobile application compared to the web-based application.

I. INTRODUCTION

Smartphones and mobile device usage has become a daily habit in the life of many, everything from reading newspaper, listening to music, communicating and interacting in social networks is easily available with mobile applications. With the use of the mobile phones equipment's such as sensors, GPS, indicators, camera, speakers etc. Several applications has been developed to offer simplicity, portability and assistance for daily activities [1]. In many aspects, developing a mobile application is similar to software engineering for embedded applications. Common challenges when developing a application are hardware compatibility, performance, reliability and storage limitations [1]. Mobile devices have limited memory, capabilities and interface components and they are highly heterogeneous [2]. When developing a mobile application there are a few more challenges that needs to be resolved before an official release. The critical lack of responsive designs and clear user interface, without impairing performance and stability for mobile devices has shown to be challenging for developers to overcome [2]. Understanding the fundamentals of the user's experience and other relevant factors such as human-computer interaction are crucial in order to create compelling interfaces that are considered engaging and drives further usage [3]. The user's opinion, willingness to learn and interaction with the system are heavily influenced by the ease of use that the user is experiencing. With a compact and responsive interface, confusion and difficulty will dissolve, allowing users to understand and use the service with less frustration. This will result in user's continuing to use and more likely enjoy the mobile application [4] [5].

A. Purpose of the study

The purpose of the study is to assess what design principles contributes to a good user experience on mobile devices. To assess this, we developed a mobile application based on design principles from other papers and did an empirical evaluation of the usability of said application, with the objective of understanding how the principles affects the user's experience. For the evaluation, users tested the developed mobile application by performing tasks prepared by the researches in advance. While the users were testing the application, they were interviewed so data could be gathered about their experience. The development of the mobile application is to offer developers the fundamental ideas about design principles in order to achieve a good user experience. In addition, we wanted to evaluate it afterwards, because this approach will not only indicate if the users obtain a better experience based on the design principles, it also lets us gather data that indicates how they work together. The design principles can have a different impacts when they are combined, it could strengthen the drawbacks or hinder the design principles. The mobile application we developed was an Android application for an existing online service. The service allows registered users to search for apartments in Sweden that are available for rent. The currently used interface for the accommodation system is a web-based interface that has limited mobile support and offers no official application for smartphones. The scope of the mobile application is to enable users to:

- Login

The system will allow the user to be able to sign in using their login credentials.

- Search for accommodation after criteria

The system will allow the user to search for available apartments based on search criteria set by the user.

- Apply for accommodation

The system will allow the user to apply for an apartment they find of interest.

- Edit their profile

The system will allow the user to configure their contact information.

- View their queue time

The system will allow the user to display their collected days and points.

- View their notifications

The system will allow the user to display any unread messages.

B. Research questions

The overall research question of this work is: "*Which design principles lead to a good user experience on mobile*

devices?" We have investigated the usability of one specific application (built according to certain design principles) and tried to derive observations from the gathered data, in order to evaluate the effectiveness of said principles. Therefore, a large part of this work is represented by a user study evaluating the usability of the application we developed. In order to scope our work, we focused on two aspects of usability, namely understandability and responsiveness. Clearly, if the users cannot understand the interface they will have problems using the application. Similarly, the user experience can be hindered if the application takes notable time to respond to the user's input. Therefore, our user study revolves around the following two questions:

1. What is the perceived ease of understanding of the mobile application?
2. What is the perceived responsiveness of the mobile application?

By interviewing the participants of the study on these two questions, we planned on deriving interesting observations pertaining the effectiveness of the design principles.

II. RELATED WORK

There have been many theoretical and practical ideas and approaches to increase user experience with the help of design principles and different methodologies. Several research papers and studies have been conducted to overcome user interfaces barriers and motivate organizations to develop applications for mobile platforms [1] [4].

Other studies have shown that if the user perceives an application to be easy to use it is more likely that they will have a more positive attitude towards it [4] [6] [7]. Because of this we choose to focus on what design principles offer a good user experience with the focus of our research question. Providers of online services are continuing to expand their services for a wider range of devices including mobile and tablets. In some cases it's the provider of the service that implements ways of using their services on new devices for example, Facebook releasing their own mobile application for the service, or a news site designing their interface to be scalable from a mobile device up to a desktop computer.

An important part of software to consider is the interaction between the user and the computer. [32] Describes this as "*a way of using a physical input/output device to perform a generic task in human-computer dialogue. It represents an abstraction of some common class of interactive task, for example, choosing one of several objects shown on a display screen.*" An important aspect of this is constant feedback from the system [8]. Something else to consider is how the user interacts with the device. There are several interaction techniques including; clicking, sliding, dragging, hovering and flipping [9]. These different techniques are different ways of sending input to the device. These techniques give the users different experience when sending their input to the device. For example, a digital book could in some interfaces be experienced better with dragging to switch page than scrolling or clicking. In this case it relates to the real action of moving your hand to flip to the next page. These different ways to give

input to the device simulate certain real actions [9] [10]. Having actions inspired by real movement gives the user something to relate to and helps the user to adapt to the interface more easily and can lead to a better experience [9]. What type of movement the user performs in order to send specific input is being considered to account for the factors mentioned, this will contribute to an more understandable and responsive product.

III. APPLICATION DESCRIPTION

The native website [11] has recently undergone a rework of its design and functionality. The website [11] allows users to register at the cost of a small fee. This will put the user in a queue system where they collect days and points for each registered day. As a registered member you can search for apartments in specific areas and apply for an apartment. The system is queue time based, that is the ones with higher registered days have a greater chance of being offered their apartment they applied for. Users can have a profile and configure their contact and personal information. They can be notified when the particular apartment they have an interest in becomes available and receive notifications regarding their applied apartments. As a non-paying user you have a set of limitations; you will not be able to collect points, days or apply for any specific apartments. You can however search for apartments available in the area and configure personal and contact information.

The native webpage lacks a mobile application and is not properly designed for a mobile device when accessing the website from a phone. The application we developed supports the Android mobile operating system (OS) which is based on the Linux kernel and currently developed by Google. The platform version that we focused on when developing for Android, was API level 21 (Lollipop) which is 9% of the population using Android OS [12]. With some few code modification we can target API level 16 (Jelly Bean) up to 21 (Lollipop) which corresponds to 88% of the Android population [12]. The application is designed to be compact, efficient, responsive and user friendly with similar functionality as the native webpage. The application uses the website as a database in order to fetch necessary information and display them on the mobile application. The application have been developed with Java and IntelliJ Studio was used as an integrated development environment (IDE). We used Github for version control to backup our code [13] and it allowed for a smoother collaboration.

A. Requirements and architectural drivers

When planning our mobile application there were a set of specifications and key features that were deemed as necessary for covering the core functionality of the application. When creating our requirements specification it was important that we avoided complex and unnecessary requirements due to time and resource limitations. We set a few functional requirements that would help us develop the application for the study with similar functionality as the website. The functional requirements that we decided on were the following:

- The user is able to login with their social security number or email address.

This requirement allows the user to sign in with their registered account on the application either with their registered social number or email address.

- The user is able to search for accommodations based on their specific criteria's.

With the application the user can search for accommodations within their specific area of choice and also have the opportunity search with filters such as maximum rent, square meters and minimum rooms.

- The user is able to apply for a particular accommodation.

After a search has been completed, the user can pick a specific accommodation and apply for it. To apply for an accommodation the account needs to be a paid membership.

- The user is able to configure their profile information.

The user can at any time change their contact information through the application.

- User can see their collected queue time and points.

The user will be able to see their queue time in the system and if they have any collected points they can see that as well. If the account has not paid their membership no days and points will be collected or displayed.

- The user can view their notifications.

This requirement lets users display any messages or notification that they have received. Only unread messages will be displayed for the user.

When developing the mobile application, intentions were to have a compact and portable application to use, we wanted to take the pivotal core functionally from the native website and build a supportive application for mobile devices. To reach the goals and increase user experience we decided to take architectural drivers into consideration [14]. Mobile devices are bound by their uniquely constrains such as the memory, processor, screen size, resolution and network bandwidth. These constraints can impose the operating system properties when an application is running on the mobile device. Users also expect a different quality when it comes to the user experience from running a mobile application compared to a desktop application. The latitude for errors tends to be less for mobile application, therefore it's important that architectural drivers are the primary objective to upsurge user experience [14]. To achieve a proper understandability and responsiveness. The following architectural drivers were taken into consideration during development:

- Performance

Certain tasks in the application requires heavy network data processing, therefore it's important to focus on minimizing the data by removing any unnecessary information that is not essential. This will also let us overcome certain problems when it comes to network bandwidth limitations. Our primary focus is to make the application run heavy tasks effective and stable without any loss of data.

- Responsiveness

We wanted to ensure that the application is always ready to respond to the user's input or external event without any tedious loading time. The response time should be similar when performed on different devices and the complexity of data should not affect the response time.

- Portability

We also focused on targeting devices with different hardware, resolution and screen sizes. This research had the opportunity to test the application on two devices with different hardware components to ensure portability. At the moment our application targets the Lollipop Android version.

B. Design principles

To impose structure and order on the design process, design principles represent guidelines that offers specific solutions to commonly occurring problems [15]. These principles helps with the decision about the way the interfaces should be structured and operate, design principles have a long history and can convince team members on the correctness of certain design decisions [15]. Design principles support designers to make decisions around their established criteria and does not prescribe the outcomes in advance. There are several important design principles and selection of the correct design principle depends on the context. We have explored several principles and have decided on a few that are going to be integrated into the application. When developing the application we wanted to design the interface to allow users perform their intended actions without issues. The selection of certain design principles' intentions were, to offer a proper composition and easy-to-navigate application with essential functionality that we developed during the limited research period. When designing the application we took comprehensibility into consideration to communicate the functionality in comprehensible manner to the user [15]. The decision to embed persistent navigation offered overview of essential content and quick access to the main functionality. We decided that implementing the Springboard design pattern was the most suitable in such short notice and would still allow us to achieve visually clear and non-intimidating navigation for the application. See Figure 1 for examples of Springboard design.

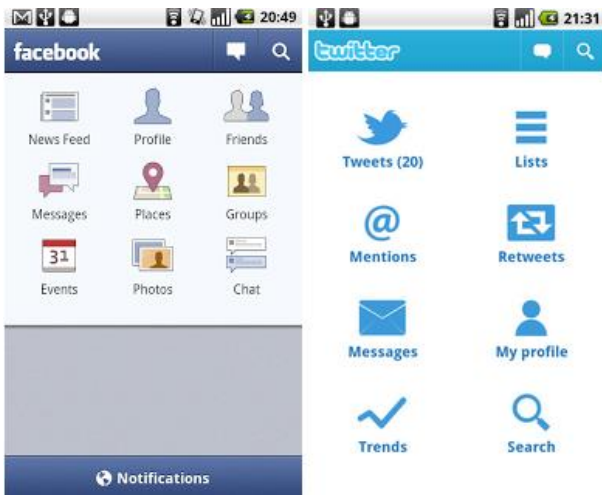


Figure 1. Applications using Springboard design pattern

To interact with the different functionality of the application we decided to implement the Springboard design with the navigation of a Hierarchical menu [15]. A Hierarchical menu is basically that we have an initial point, from it, the user selects their options that sends them to the next page with this process repeating until they have reached their goal [15]. For the options menu page and the page where the user inputs their criteria for the kind of apartment they are looking for we decided to implement the design based on Form fill-in [15]. Form fill-in are used primarily to gather information and tries to resemble the look of paper forms [15]. Both the options page and the page where the user inputs their criteria for the apartment search contains several information fields that the user can fill in. On the options page it's already filled in with the currently used settings, these settings can be changed by replacing the content of the specific field and press the save button. The search page will show its form with several of its fields entirely empty like the maximum rent but will also have a few fields with a default option already selected that the user can choose to change.

The intention of the mobile application is to interpret the user's input to perform certain actions in a way that is natural to the users [9], for instance altering the menu or page from one state to another [9]. The main menu of the application is based on the Springboard design and it includes the navigation options as buttons in a grid-like manner. Considering the navigation options being buttons, it was interpreted that the most natural way of input for this element type were pressing it [8] [10]. This translates to pointing on the screen and at least lightly touch the screen as the screen can't be pressed down in an area to fully simulate button pressing. Certain pages of the application interface can on devices with smaller screens contain more elements than can fit on the screen at once. To allow a larger range of devices of different screen sizes, support for scrolling on the pages were included. Scrolling on a page in the application will only work if the screen is not displaying the entire page at once. A real world scenario of scrolling that was used was reading a real paper. The natural action to interact with the paper to be able to follow the text further down the page is to move the paper up to enable the reader to view the text further down. This action could be

translated to dragging upwards on the screen to rise the page. Also, with the help of the Android simulation tool that was provided from IntelliJ, we could test several devices with different screen configurations to offer portability. To increase overall user experience we wanted to create consistent navigation with responsive transitions and short loading times. We decided to follow certain design principles to overcome recurring design problems, e.g., in a process tunnel, progress status should be readily visible to the user. The application should prevent errors from happening, but when errors occurs, adequate guidance needs to be provided in order to help users resolve them [8]. Therefore, the application is designed to provide notifications when a certain operation provides insufficient result, e.g., The application alert the user when incorrect credentials have been used and suggest that the user attempts to try again with correct credentials. In addition, when the user updated their contact information and saves, the application shall notify the user that information have updated. When navigating through our application and performing an apartment search, the application offer the user all relevant information without having to move between extra screen in order to find the information, this should be more convenient for the user and will conserve time. Having a consistent design is simpler for users, because it re-uses behaviors, colors, icons, components, and aesthetic to reduce the need for users to rethink [15]. Many of users are familiar with components that they have used throughout their daily lives or other applications, so using similar design principles that will make the application simpler and clearer [15].

C. Implementation

The implementation of the accommodation application is carried out using a Java as the target language. The selection is mainly based on practical reasons, Java is a known programming language which has support for Android development with up-to-date documentations. The language offers a lot of extensive libraries and tools for specified application areas that help developers to save time and resources. For the development of the application there was no existing API that was provided from the web page. In order to gather and process the necessary data that we needed from the webpage, we decided to use the Jsoup library [16] that provided stable and convenient API for extracting and manipulating data. This research was limited with time, so note that the application is developed as a prototype. The prototype does elaborate all aspects of the requirements and design principles. The application's source code is available at the project's Github repository [13] and was used repetitive when developing to avoid loss of source code and the possibility to reverse any changes that are unstable. We will provide a brief summary on the core functionality, full view of classes and implementation are available at Github [13]. When developing our prototype we decided to implement one main class that's primary function is to obtain, extract and manipulate data from the website by using the Jsoup library [16], the class is defined as Crawler. By adding all the essential functions in one class, we can then maintain the application easily if any other functionality needs to be implemented in the future. The Crawler class has a set of functions that are called from other classes, see Figure 2 for the primary functions.

Crawler
<pre> + cookie : String + sUrl : String + searchResults : ArrayList<ArrayList<String>> - loginUrl : String </pre>
<pre> + login(String userName, String password) : boolean + getUnreadMessages(String cookie) : ArrayList<String> + getUserName(String cookie) : String + getContactDetails(String cookie) : ArrayList<String> + getDays(String cookie) : String + getHSB(String cookie) : String + search(String itemType, String rent, City city, String rooms, String area, String location, String squaremeters, String objectType) : ArrayList<String> </pre>

Figure 2. The functions of the Crawler class

The Crawler class obtains data and filters any unnecessary information out, the data is then sent out to the specific class that called the function in the Crawler class. The Crawler class has no interface and its primary activity is to provide necessary data for the interface classes. A rather challenging part of this research was to create a functional API that could extract data based from the web-based application, the service does not support any external API's that can be used by other-parties. With no official API, we decided to scrape essential information from the website by sending requests from the application to the service. The application receives much of its information by requests. Also, to receive and change user specific information the application will have to first have a valid session to the service. To get this session information, the user will have to login using their credentials to the service. If the credentials are correct, the service will return a session key that can be sent with any other request to the service to identify the user and allow the service to send relevant information for the specific user in response. This session key can be used to receive information about the specific user, for example how many points they have collected at the service or if they qualify for the criteria of an accommodation. Sending the session key with a request also permits the user to change account details from the application. The unreliable part of data extraction method is if the website decided to modify their source code that is being used by our application, the application has a high risk of not being able to find the requested information. Therefore, by structuring all our commonly used data request functions in the Crawler class, we can rewrite our code in one place and minimize the risk of code update segregation between the components. The Github repository [13] offers a full overview of the source code and pictures of the prototype.

IV. METHODOLOGY

The focus of this section is to describe and discuss the specific methodology and research method that has been chosen for this particular study. In addition steps for gathering the data will be provided and evaluation of the collected data will be presented in this section.

A. Research strategy

For finding out the possible answers related to the research question in this study, planning and designing is a necessary

step that had to be taken into consideration. The research strategy must contain diverse methods and tools that can support or guide the study to achieve its final objective. It's important for researcher to utilize the tools and research methods that outlines the reliability and validity of the data collected throughout the research. In addition, it's critical to inspect and analyze all material and collected data. The data collected from the mobile application and web application survey will be analyzed and a discussion will be held later in the research to identify critical results, conclusion and future work will be drawn based on the results that are related to the research question. For this study the research question were decided by studying related work and responsive user interfaces for mobile applications.

B. Selecting method

The most common research methods are identified as quantitative and qualitative methods. These methods provided necessary support and guidance when carrying out procedures to collect data [17]. When choosing a quantitative approach the data is collected and transformed into numbers, with the assistance of mathematics and statistical tools empirical relationship can be discovered that can later be discussed in conclusion [17] [18]. A short description of quantitative approaches is that they are related to numerical interpretations. Qualitative research focuses on in-depth understanding of experience, perspective and social interactions instead of numbers [17]. Qualitative research aims to understand aspects in social life and is used to generate words rather than numerical values. Qualitative research is mostly appropriate for research where the quantitative method fails to observe essential information where numbers are not sufficient [17].

For this research a quantitative method was selected due to nature of our research question, we decided that measuring the phenomenon of experience by numbers allowed us to answer the research questions properly. The quantitative method allowed us to measure the different user experiences in order to observe their opinion of the used design principles. In addition, this research also used a qualitative approach to understand social interactions, opinions and interests that are essential to this research. The usage of a qualitative approach provided us with underlying factors that would have gone unnoticed. This helped us to understand the fundamentals of user experience and provide us with the necessary information in order to determine which design principles that can be used to permit a good user experience on a mobile application.

For the study we used structured interviews. The strengths of structured interviews are that all the participants are asked identical questions and in the same way. This approach makes it easier to perform the interviews in a standardized way and makes it easier to compare the answers within the sample and against another sample with identical questions. Many of the interviewees came from different cultural background and required us to be prepared for possible misunderstandings that could occur. By having clear and precise questions and making sure that the participants understood the questions and whether the researcher understood their answer correct can reduce the risk of misinterpretation [19]. With interview we had the

possibility to observe emotions and social interactions were other methods are limited to this [17] [19].

After planning and structuring the interview, a pilot test was conducted in order to test the structure and questionnaire. Based on the pilot test we made some minor adjustments in the questionnaire. The questionnaire had both closed and open-ended questions with predefined answers for the closed questions. To understand what relevant open ended questions that would be used for our research, existing literature and background was studied thorough. The gained knowledge allowed us to understand the concept of design principles and gave us proper insights for creating relevant open ended questions.

The questionnaire and interview avoided gathering any background data of the participants and it was explained that the information collected would be confidential in this study. This establishes an increased trustworthiness between the participants and the researchers allowing for more reliable and valid data [20].

C. Population

The segment of the population that has been selected for this research paper or in other words the sample is based on a random selection method for this particular study. We managed to collaborate with 27 participants in total, every third participant was assigned to test the web application and the rest was selected to test the mobile application. Out of 29 asked we had 2 potential participants turning down the offer to be part of the study. The targeted sample consisted of 10 females and 17 males where age differed from age 18 - 59. The individuals had an above average technical expertise to different degrees. Their knowledge about the accommodation search system diverged from visited a few times to minor use of the search system.

D. Conducted interviews

For this research, 27 participants were interviewed in total. Every third participant that were interviewed was selected to test the web application, the rest of the participants were assigned to test the mobile application. 7 responses was collected for the web application and 20 for the mobile application. All conducted interviews were conducted in English and anonymity was provided to the participants. Each interview took between 30-40 minutes to perform. During the interviews the participants tested the selected application on a mobile device and answered the questionnaire [21] [22]. The participants were asked to perform a series of task related to the chosen application [23]. After each performed task, questions related to the tasks were asked, once the interview questions related to the tasks were completed, additional questions was asked. See section 4.5 for description of interview questions. To ensure the quality of the tasks and questions a pilot test was conducted. This helped us see if the tasks and questions were understandable and also to ensure that the structure is appropriate and if changes are necessary. We decided to have a test account prepared for the interviews to reduce inconvenience and allow them to configure the account without constraints. The tasks instructions are written in short and direct way and the interviewee was allowed to see the tasks

description at any moment during the interview. An example of one of the tasks is Task 1 as described:

1. Start from the login page.
2. Login using "testobjekt@mailinator.com" with the password "123456"
3. Search for where it indicates your first and last name

After each completed tasks notes were taken if the user was able or unable to complete the specified task.

E. Interview questions

During the user test of the application the user were asked 5 questions after completing each of the 7 tasks. These 5 questions were identical for each task and were included per task to more easily identify what areas of the application that was satisfying and which were not satisfying. The 5 questions that were asked after each task were:

- Was the user able to complete the task without help not included in the instructions?
- How difficult was the specified task to perform?
- How clear was the interface experienced when performing the specified task?
- How difficult to navigate was the application when performing the specified task?
- How responsive is the interface when performing the specified task?

The first question is filled in with either yes or no based on if the user required additional information than the task instructions provides. The other questions are answered by the user selecting a number from 1 to 5. The lower numbers indicates that the user does not like it or it's very bad while higher numbers indicate that the user likes it or it's very good [21] [22]. The two first questions are control questions with the purpose of indicating if the task was well formulated or not. If these two questions receive a low score from the samples then the questions are not clear enough. The score for these questions will be determined by the median value. The questions with the word responsive is used to measure the time it takes to provide a response to the user's input [33] [34]. If the user experiences that they receive acknowledgment immediately after performing an input they will experience it as responsive to some degree based on their expectation [34]. [2] [15] In addition it's important that the response is appropriate and concise, if the user does not notice the response they might value the application as unresponsive [2] [15] which should also be considered. After the user has answered the questions related to specific tasks they will have 5 questions about how they experienced the application in general during the tests. These 5 questions are:

- In general, was it easy to navigate in the application?
- In general, was the application experienced as reliable?
- Would you use this application in the future?

- What would you like to see improved?
- What features/aspects did you like?

Similar interview questions were asked for the web-based application, only minor words were changed such as “application” to “website”. The word reliable is defined as the ability of the unit under set conditions and for a specified time to perform necessary functionality [33].

1) Related to perceived ease of understanding

The interview questions that are related to the first question, “What is the perceived ease of understanding of the mobile application?” are;

- How clear was the interface experienced when performing the specified task?
- How difficult to navigate was the application when performing the specified task?
- In general, was it easy to navigate in the application?

The questions above is related to the question “What is the perceived ease of understanding of the mobile application?” because how clear the interface is experienced affects the user's ability to understand the interface. The second question is related as how easy it is to navigate in the application is based on the user's understanding of where they expect to find what they are looking for.

2) Related to perceived responsiveness

The interview question that relates to the second question, “What is the perceived responsiveness of the mobile application?” are;

- How responsive is the interface when performing the specified task?

3) Related to improvement

The open-ended interview questions are not always related to a specific question, but could relate to them depending on the user's feedback. The data from the open-ended questions could in some cases not relate to either of the questions directly, but could still be of use to identify design principles that leads to a good user experience. This data can also be of use for future studies as these questions are about what the users experienced as satisfactory and unsatisfactory parts of the product. By looking into the responses on these questions, an improvement plan can be proposed that could be used as basis for future studies. The questions that falls under this category are:

- What would you like to see improved?
- What features/aspects did you like?

F. Null hypothesis

- H0 understand - There is no difference in ease to understand between the interfaces.
- H1 understand - There is a difference in ease to understand between the interfaces. The mobile application is easier to understand.

- H0 responsive - There is no difference in the responsiveness between the interfaces.
- H1 responsive - There is a difference in the responsiveness between the interfaces. The mobile application is easier to understand.

G. Analysis

In this section explanation of our quantitative and qualitative tests and methods will be presented, based on the findings a discussion will be held later in the paper and conclusions will be drawn upon that. The aim of this section is to gather the necessary findings in order to answer our research questions.

1) Quantitative $H_{Understand}$ and $H_{Responsive}$ Test

To analyze the understandability and responsiveness of the interface for the mobile application the application will be compared against a smaller sample of users testing the web-based service on a phone. As the interview questions level of measurement were of the type known as Likert scale resulting in ordinal data. Selection of Mann-Whitney U-Test [24] [25] [26] was deemed to be the most suitable analysis method due to data being ordinal. The two samples are compared against each other on a per question basis. After the Mann-Whitney U-Test have been performed on a question the results will be checked for the U-value and critical U-value of the test. The result is only significant if the U-value is equal to or less than the critical U-value, else it's not significant. After all the questions have been processed and checked if they are significant or not the results will be grouped together on a per research question basis. These results of if it is significant or not will be given a value, 1 for significant and 0 for insignificant. These numbers will then be checked to see the median for the research questions [27]. If the median value is 0, insignificant, then the H0 of the hypothesis cannot be rejected. If the median value is 1, significant, then the H0 of the hypothesis is rejected. Median was selected as the measurement to compare the two samples with each other to see which one was experienced better by the users if the Mann-Whitney U-Test results in a significant result.

2) Qualitative analysis

For our qualitative data we used techniques such as coding and creating chain of evidence based on the original data. The coding approach is a process that categorizes and sorts the data. It offers a way to label, compile and organize our data [17] [20]. A selection of text will be labeled by using a one-word code as known as descriptive code, which categorizes and sorts the data. By following this approach it allowed us to more easily find similarities and patterns in our qualitative data [17]. In case that any of the qualitative feedback relates to the design or the design principles, that information will be used in conjunction with the quantitative data to evaluate the used design principles. This information can offer guidance and suggestions on what design principles should improve or be implemented in order to see which design principles lead to a good user experience on mobile devices. The same information will give us an insight into what the users

themselves believes they want from a graphical interface on mobile devices and which design principles that contributes towards it. The design principles should effectively weave together a combination of text, graphics, layout and interactive elements to ensure users have a positive and less frustrating experience.

V. RESULT

The result is based on 26 user tests with interviews. 19 of these 26 are part of the application sample and 7 are part of the web-service sample.

A. $H_{Understand}$ Results

The first of the interview questions related to the research question is “How clear was the interface experienced when performing the specified task?” This question is answered 7 times for each participating user. This results in 7 calculations using the Mann-Whitney U-Test. The results of these calculations are;

- For task 1, the median response in groups application and web-service were both 5 on a scale from 1 to 5 where 1 is a very bad experience and 5 is a very good experience. The Mann-Whitney U-Test on the samples shows insignificance, the $H_{0_{Understand}}$ cannot be rejected for this test.
- For task 2, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows insignificance, the $H_{0_{Understand}}$ cannot be rejected for this test.
- For task 3, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.
- For task 4, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows insignificance, the $H_{0_{Understand}}$ cannot be rejected for this test.
- For task 5, the median response in groups application and web-service were 5 and 3 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.
- For task 6, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.
- For task 7, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.

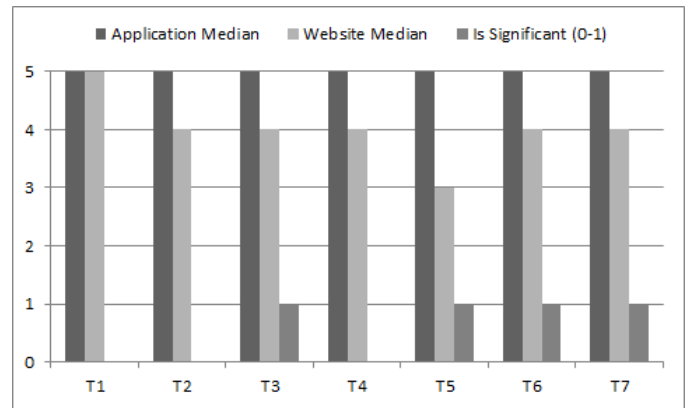


Figure 3 of the result of the question “How clear was the interface experienced when performing the specified task?”. The letter “T” is short for task.

The second interview question related to the research question is “How difficult to navigate was the application when performing the specified task?” This question is answered 7 times for each participating user. The results of these calculations are;

- For task 1, the median response in groups application and web-service were 5 and 3 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.
- For task 2, the median response in groups application and web-service were 5 and 3 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.
- For task 3, the median response in groups application and web-service were 5 and 3 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.
- For task 4, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows insignificance, the $H_{0_{Understand}}$ cannot be rejected for this test.
- For task 5, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.
- For task 6, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows insignificance, the $H_{0_{Understand}}$ cannot be rejected for this test.
- For task 7, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{Understand}}$ can be rejected for this test.

One of the questions about the interface in general that were related to the research question. The question were “In general, was it easy to navigate in the application?” The results on this question were;

- The median response in groups application and web-service were 5 and 3 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{\text{Understand}}}$ can be rejected for this test.

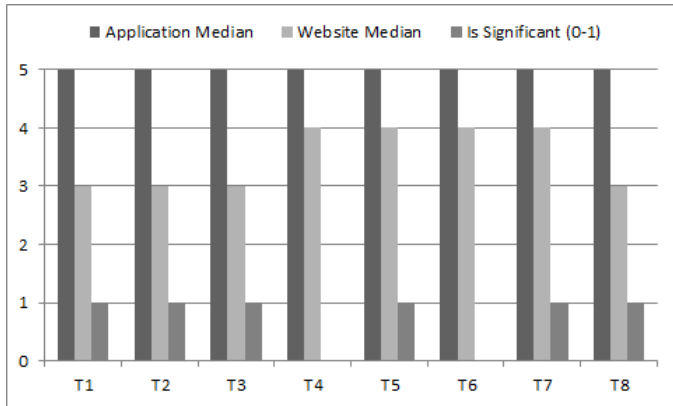


Figure 4 of the result of the question “How difficult to navigate was the application when performing the specified task?”. The letter “T” is short for task. Note that task 8 refers to the question “In general, was it easy to navigate in the application?”.

B. $H_{\text{Responsive}}$ Results

The task question related to the research question is “How responsive was the interface when performing the specified task?” This question is answered 7 times for each participating user. This results in 7 calculations using the Mann-Whitney U-Test. The results of these calculations are;

- For task 1, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{\text{Responsive}}}$ can be rejected for this test.
- For task 2, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{\text{Responsive}}}$ can be rejected for this test.
- For task 3, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{\text{Responsive}}}$ can be rejected for this test.
- For task 4, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows insignificance, the $H_{0_{\text{Responsive}}}$ cannot be rejected for this test.

- For task 5, the median response in groups application and web-service were 5 and 3 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{\text{Responsive}}}$ can be rejected for this test.
- For task 6, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows insignificance, the $H_{0_{\text{Responsive}}}$ cannot be rejected for this test.
- For task 7, the median response in groups application and web-service were 5 and 4 on a scale from 1 to 5. The Mann-Whitney U-Test on the samples shows significance, the $H_{0_{\text{Responsive}}}$ can be rejected for this test.

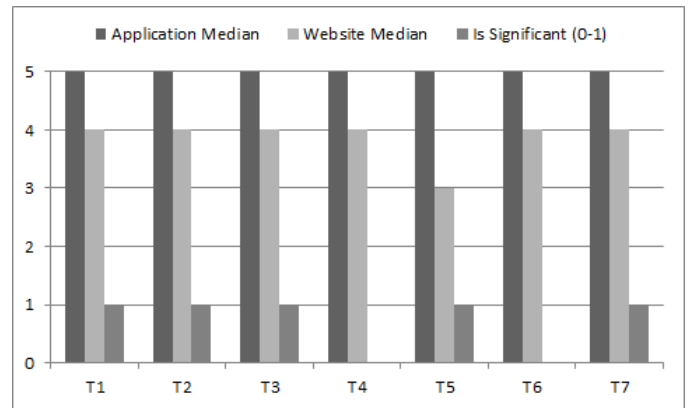


Figure 5 of the result of the question “How difficult to navigate was the application when performing the specified task?”. The letter “T” is short for task.

C. Qualitative results

In this section we will discuss the findings from the web-based and mobile application based on the questionnaire question “What would you like to improve?” After categorizing and finding similarities based on the qualitative data, tables has been generated to summarize the results. Figure 6 shows the result of the mobile application and Figure 7 shows the results from the web-based application survey.

Mobile Application Sorted Comments	Similiar Comments
Performance issues when performing a search	4
Swap picture between the search and searched button in main menu.	1
Unkown if account is free or premium user, add information on membership status	1
Correct information alignment when displaying search result (rent, floor, size etc.)	3
Implement loading indicators when performing a action	5
Rearrange the position of first and last name	4
Add additional pictures and blueprints for apartments	2
Add a home button that goes to main menu	1
Font size modification is needed	1
Specify why requirements are not fulfilled	2
Social media interaction	1
English implementation of the system	2
Verifaction for email, name, phone etc	1

Figure 6. The numbers indicates how many similar opinions was found from the mobile qualitative data. Comments that have been commented several times, have a higher priority.

Web Service Sorted Comments	Similiar Comments
Implement Mobile Support	5
Filter boxes does not disappear when trying to set specific criterias	4
Problem when signing in. Login button bugs	5
Hard to navigate, buttons are to small	2
Rephrase the word "trappa" to "våning"	1
Merge account and contact settings in one place	1

Figure 7. The numbers indicates how many similar opinions was found from the web-service qualitative data. Comments that have been commented several times, have higher priority.

Both Figure 6 and Figure 7 indicates that participants have similar opinions when it comes to certain persistent in the application, the higher numbers indicates that these critical problems may need to be addressed within a short time. The results demonstrated above contains feedback that is in most cases associated to the design principles. The ones associated to the design principles are categorized into;

- Performance issues when performing a search.
- Swap picture between the search and searched button in main menu.

- Implement loading indicators for when performing an action.
- Rearrange the position of the first and last name.
- Add a home button that goes to main menu.
- Hard to navigate, buttons are too small.

How they associate and what implications it have on the evaluation of the design principles will be discussed under section VI (Discussion). The question “What features/aspects did you like?” gave us an insight on what the participants found enjoyable when using the specified application. The understanding of the different likeable features in the applications is similar to the improvements in the opposite application. The main objective of the questions "What features/aspects did you like?" was to act as a control question, to see what features were lacking in the opposite application. With the data we could try to provide similar characteristics or qualities when implementing any future improvements and will also be used to evaluate the design principles. No particular analysis method was used for these questions, but similar comments was taken out and summarized in a table for easier understanding, see Figure 8 for result.

Mobile Application Good Features	Website Application Good Features
Compact and responsive	Detailed pictures for apartments
	Why the requirments are not fulfilled is shown
Easy to login	High Performance
Font and design is clear	
Necessary information is provided	
Easy to apply for an accommodations	

Figure 8. Popular features for the website and mobile application.

VI. DISCUSSION

The discussion is divided into 3 sections. The two first are related to the two questions that the study revolves around. In these sections the quantitative data is discussed and when possible connected to the participating users qualitative feedback. Section 3 is focused on the qualitative feedback, not all qualitative feedback from the users can easily be connected to the quantitative data but can still include information relevant to evaluate the implemented design principles.

A. Perceived ease of understanding

To evaluate the research question “Which design principles lead to a good user experience on mobile devices?” through the question “What is the perceived ease of understanding of the mobile application?” We evaluated 2 of the interview questions that were asked once per task and one of the questions related to the interface in general.

The result of the question “How clear was the interface experienced when performing the specified task?” shows that the result were significant on every task except for task 1, 2 and 4. Task 1 received a median of 5 in both interfaces in clearness, indicating that users of both interfaces experienced both designs as very clear.

Task 3 showed a significant difference in responses between the samples, users indicated that the interface of the mobile application was perceived as clearer. The median

response of the application testers were 5 while the median for the web-service were 4, indicating that the web-service testers found it more unclear. The observed data gathered provides suggestions that are related to the tasks, following suggestion are mentioned; “The contact settings should be merged with the account settings” and “Confusion with profile”. This feedback indicates that the reason users are experiencing the web-service as unclear is because that there are several settings menus on the web-service and users are having problems identifying which menu they are supposed to find the option they are looking for under. The application on the other hand is not observing this interference as it have these two menus merged in this interface. As [15] states, it's important to have a comprehensible interface that express the core functionality of the system, and that a system is compact but still offers full functionality without inhibiting performance and understandability. The web-service fails in this aspect by splitting up its menus into several sub-menus with names that have similar meaning, resulting in confused users.

Task 4 showed an insignificant difference in response between the samples. The median of the mobile application sample was 5 while the median for the web-service sample was 4. While the difference is insignificant these two medians are both high, indicating that finding where to search and searching with only the area as a condition were about equally good in regards to how clear it was. Task 5 to 7 are about searching but with more conditions and are significant. This could indicate that the mobile applications design is better in comparison to the web-service in some element that is not part of task 4. Relevant suggestions observed from web-service interviews concludes the following “*Hard to press some buttons and some filter boxes are in the way when doing search.*” This pinpoints the reason users of the users of the web-service pick less clear options than the mobile application. Assuming it's hard to interact with a button due to immense preciseness on a rather small screen with small components, this can be hard to cope with and can be less clear.

The result of the question “*How difficult to navigate was the application when performing the specified task?*” shows that the result were significant on all the tasks except for task 4 and 6. Task 1, 2 and 3 all had a median of 5 for the mobile application and 3 for the web-service, indicating that the users testing the application had a better experience of trying to navigate in the mobile application compared to the web-service. The reason for a worse experience of using the web-service could be partly because of reported problems with using the web-service. Users testing the web-service reported “*The login popup were glitching and not visible for 10-20 at least seconds after pressing login.*” and “*The website is too large to fit on a phone screen, you have to zoom in a lot to see anything*” among the feedback related to these tasks. This feedback suggests that the website is built with large elements considering the viewing device being a phone. Assuming the uses have to zoom in to see anything they will also have to drag on the screen to move the area of the webpage that are visible. This can be considered difficult when trying to navigate to the page that the user are looking for. The use of Springboard design pattern allowed for a visually clear and persistent navigation in the mobile application. As [15]

mentions, this enables our design to allow users to successfully accomplish tasks without having to do overly extraneous steps. In addition, it's more likely that the user will then perceive the application as understandable and have a more positive attitude towards it as [4] [6] [7] states. This issue related to the login popup window on the web-service also shows us the importance of making sure that the user gets feedback constantly based on their input as the users will find it frustrating when their input does nothing when they expect it to give them feedback [15].

Task 4 and 6 showed insignificant for this question, similar to the previous question about clearness. The tasks 5 and 7 are also about searching, but shows significant difference. Task 4 and 6 could be insignificant because the tasks necessary elements are rather good on both platforms while the elements that task 5 and 7 requires are experienced as better on the mobile application.

From these questions on these tasks we can see that the mobile application is experienced as at least as clear as the web-service in a few aspects while in the majority of the cases the mobile application is experienced as more clear. Feedback from the users like “*The contact settings should be merged with the account settings*” and “*Hard to press some buttons and some filter boxes are in the way when doing search.*” for the web-service helps to inform us of what to consider for changes to the mobile application to make it an better experienced alternative to the users for the service and also shows what design principles are experienced better by the users in mobile applications. From these tests 12 out of 15 were significant, giving us a clear median of significant. In all of the cases of significant the mobile application had 1-2 higher in median value, indicating that the mobile application where experienced as more easy to understand than the web-service. This indicates that the product were a success from an understandability standpoint.

B. Perceived responsiveness

To answer the research question “*Which design principles lead to a good user experience on mobile devices?*” through the question “*What is the perceived responsiveness of the mobile application?*” We analyzed 1 of the interview questions that were asked once per task. The result of the question “*How responsive was the interface when performing the specified task?*” shows that the result were significant in all cases except for task 4 and 6. Task 4 to 7 are about searching, when 2 of the 4 tasks shows insignificance, it could indicate that there is a restriction or inconvenience with the interface that identifies the mobile application as slow and less responsive. From the improvement feedback for the mobile application we can find relevant feedback “*When you press the search button there is no indication that it does anything until the results jump up after 1-2 seconds*”. This reinforces the design principle of constant feedback from the system as an important part as described by [8]. The application could be experienced as less responsive, due to the lack of indicators the user is uncertain if the application has received the user's input and performed a search after interacting with the button. The application is also observed to be slow when there is 25 or more results being displayed and takes much longer to load. Integrating loading

indicators and increasing the overall performance of the search functionality would improve the experience and pinpoint the application as more responsive. From these questions on these tasks we can see that the mobile application is experienced partially as responsive as the web-service in a few aspects while in the majority of the cases the mobile application is experienced as more responsive. From these tests, 5 out of 7 were significant, giving us a clear median of significant. In all of the cases of significant the mobile application had 1-2 higher in median value, indicating that the mobile application where experienced as more responsive than the web-service. This indicates that the design principles implemented resulted in a better user experience from a responsiveness standpoint.

C. Qualitative improvements

The open-ended question “What would you like to improve?” allows the participants to give their opinions and comments on what can be improved on the targeted application they were asked to test. Participants who decided to mark a lower score on certain tasks had the opportunity to express and comment on what design principles the developers could implement or improve to offer a more rich experience. Improvements suggestions that were provided for the web-based application were used to see what participants disliked, with the information we could then focus on the limitations of the website and overcome the flaws of our application.

1) Constant feedback

Based on the findings, we found out that several people were struggling with performance when performing an action but it did not appear to happen for every user. The findings related to the responsiveness of the apartment search were:

- “Lag issues when searching for apps and opening specific appartement pages.”
- “When searching for apartment it's a little slow but maybe due to all data?”
- “Maybe disable button or add some loading bars”.
- “Super responsive and no bugs found.”

The findings shows a few cases of users experiencing issue with the time it takes when performing a search but we can also see from the feedback that it is not an issue for every search. Based on observations when testing the mobile application, the time it takes for the application to perform a search increases greatly when there are more than around 25 results returned to the user. With the number of feedback associated with this issue we can clearly see that users based on the samples wants their input to get a response immediately or within a very short time period based on their expectations of how long time they think it should take, showing the importance of considering constant feedback from the system to the user's input [8]. As some actions require some time to perform and can't return their result immediately it is important that we give the users an indication in the meanwhile to indicate to them that their input have been recognized. Based on the user feedback it could be done by displaying a short message like “searching...”, disable the button until the application is done with that action and add a loading bar. These indicators among others should be

considered when dealing with actions that can take noticeable time to perform to give the user the experience of constant feedback

2) Familiar position

During our interviews we noticed that participants struggled with the first task, finding the first and last name in the application was rather hard for a few participants. The feedback related to this issue were:

- “display both the text boplat AND your name.”
- “Had some problems finding first and last name, change position?”
- “Maybe move the first name and last name to better place?”
- “The bar at the top of the app should display either "boplat", your name or both”

The feedback shows that many of the users was struggling with finding the first and last name in the application, this can be due to the users being familiar with having logos in the corners and having profile information in the profile menu can tend to be more natural for the users then the corners [15] [9].

3) Springboard Design

The use of Springboard in our design were experienced as positive. By using a compact and clear design with large icons we are able offer the user good navigation and they do not have to rely on precision as much as they need on the web-service. The relevant feedback are:

- “Clear and compact navigation. Easy to search and configure profile. Easy to understand, (Big buttons and text).”
- “I like the big navigation buttons and the main menu, allowing me to see queue time and points easily. Can check apartments with just a few clicks”

4) Hierarchal

As the navigation between the pages are designed in a hierarchal way where the user can only reach certain pages by selecting specific options we have to consider how the users can get back to the main menu from the page they are currently at. Some users experienced that it took too long to get back to the main page. This would indicate that there were negative aspects to implement the navigation based on Hierarchal menu. To reduce the negative impact of when the user will have to backtrack many pages to get to the main menu one of the users suggested “Home Button (To save me time by clicking back to go from an apartment page to the main menu).” Adding a home button that would take the user back to the main menu could reduce any potential frustration from having to press the back button several times.

The answers that were obtained from our open-ended questions can also be used to increase the quality of our mobile application in the future, the use of different color coding enables us to prioritize and categorize the suggested improvements based on the number of feedback from the participants. The integration of the improvements may result in

a better experience for the users and can be measured again in future studies if resources are available.

VII. VALIDITY THREATS

When having a structured interview with qualitative approach, reliability and validity are critical to take into consideration when doing a study. The level of credibility and quality of the research can be measured by the reliability and validity of the study. The two different measurements can be separated into internal and external concepts [18]. Internal reliability means if there are more than one researcher when conducting the study, external reliability refers to what extend a research can be accomplished with similar results [18]. Often it can be difficult to achieve stable and high reliability since environmental changes are likely to change from when the original research was conducted to the time of a second one. In order to allow this study to be recreated we focused on describing in-depth details on how data gathering and interviews were performed [18]. With the particular details there will be higher chance for future researchers to recreate this study. Internal validity defines to what degree the researchers in the study are able to agree and come to terms with the gathered data, discussion and conclusion. External validity are often seen as a problem in qualitative research, generally the researchers makes the assumption that the findings can be used in other social environments and qualitative study uses small samples and case studies [18]. For this thesis we took notes and allowed the interviewers to input their opinions manually with the use of our survey. In order to increase validity we asked for approval from the interviewee once the data was gathered.

Some general problems when conducting structured interviews with the use of open ended questions, the interview can be directed by the interviewer's opinion and interest. Structured interviews offers organized and often isolate other issues that are not related to the topic. With structured interviews there is a smaller chance that misunderstandings and misinterpretations occur during an interview. In this research many of the interviews that have been conducted was in English which is not the mother language of several interviewees. Due to lack of recordings and transcription there was a greater chance that the reliability of the open-ended answers was not precise or misinterpreted. However, in order to increase the reliability of the answers in the conducted interviews we took notes and both researchers always attended. Once the interview was completed comments, notes and the survey choices was confirmed by the interviewees to reduce misleading data. The choice of research topic and limited time, sets a restriction for our sample size.

There is a huge fraction of people that are looking for apartments in Sweden. We only had the opportunity to gather information from a few participants. Thus, It's possible that our sample size is too insignificant resulting in difficulty when representing the population as a whole [28] [29].

Selection bias needs to be taken into consideration for this study as well. Sample characteristic can have critical effects on external validity. When choosing people for the interview, there is a possibility that the participants are too familiar with

the experience of using an accommodation search system, in that case the result won't reflect that of the normal people that have average experience with the specified system [30] [31].

The researchers observed that nearly all of the participating testers in both samples had a positive bias. The users wanted to select rather positive options, even if they experienced problems trying to complete a task. Unless the user were experiencing enough trouble to be very frustrated or even start cursing they always selected either option 4 or 5(the two highest). If the user becomes frustrated they would usually select an option 3(average or ok). The users were not informed by the researchers as to any outcome they desired from the questions to prevent bias towards a specific platform.

VIII. CONCLUSION

We started this research with the aim of understanding what design principles contributes to a good user experience. The study decided to develop a mobile application built according to certain design principles to help us assess our research question. In addition an empirical evaluation of the usability of the application was done to collect adequate data to answer the research question "*Which design principles lead to a good user experience on mobile devices?*" The comparison between the mobile application and the web-service indicated that the mobile application was experienced as more understandable and responsive, this demonstrates that the implemented design principles appears to lead to a good user experience for a mobile application.

The design principles that we decided to explore and implement were to offer a proper composition and easy-to-navigate with quick access to the essential functionality. This research managed to identify which of our used design principles lead to a good user experience, by observing the interviews and analyzing the data. We identified that the users expects to get a response to their input immediately or within a very short time period depending on the task. Based on this we consider constant feedback to the user from the application to be an important aspect of the design.

The standpoint of making the interface feel more natural and intuitive to use though basing the input methods on real world examples and actions were not noticed by the users except that they expected to be able to scroll by pressing on the scrollbar on the right side that appeared when the user started to drag the screen up or down to scroll. This confusion comes from the desktop computer usage habit and resulted in some minor frustration. We would recommend to be careful with any visual indicators for when the user are zooming or scrolling on mobile devices as users that are used to desktop computers might try to interact with the indicators directly, resulting in frustration if they have no direct input function.

The hierarchical menu based navigation were not noticed except when trying to go back to the main menu in the cases where the user have to press back several times. If an application requires the user to press back many times to get back to the main menu we recommend that a home button or similar feature to be implemented. This can reduce the frustration from the users when they want to navigate to a

different page in the application and result in a better experience.

The use of Springboard in the design was well received by the users. They approved of the use of a compact menu with large icons to press, it was experienced as equally clear to understand as alternatives but was considered easy and fast to use.

A. Limitations

A significant limitation on the study is the limited time. This study could only go on for 10 weeks which limits what can be done. Certain research methods like experiment could not be considered because of the time it takes to conduct it. The time limit also limits how much functionality can be developed for the product, with more time more functionality could have been developed. The quality of the developed product could also be improved with more time for looking into alternative implementations for functionality that could lead to more memory and processing conservative implementations. The time limit also prevents us from being able to update the product based on the feedback from the user tests and interviews and run a second iteration of the product. The limited time also limits how many users we have time for interviewing, with more time we could have larger samples. Another aspect that can be seen as a limitation on the study are the use of a single phone model for conducting the user tests and interviews. While having a single phone model keeps some factors from being different between the tests like screen size it also limits the feedback that are received during the interviews. There might be undiscovered errors that could have been found and corrected before the product is released if the users got to test it on different devices.

B. Future Work

For future research on this subject, we would like to gain more knowledge on the findings and overcome limitation that was encountered during our research. We wanted to do further research after improving or implementing design principles in the application to increase user experience, and allow the participants to test application after the improvements have been conducted. The mobile application's functionality and interface can be improved on certain areas, for future plans we would like to implement an English version of the application. Implementing the English version should have been a priority in the early stages of the research but was not implemented, due to limited time. The use of an English version would be better for participants who did not have English as their native language. Therefore, the risk of misinterpretation would be lower. We noticed that participants that navigated through the application felt confusion during specific locations in the program, there were no indicator that the application was loading, resulting in participants not knowing if the application responded to the user's input. We came to the conclusion that if implementation of loading indicators would have done, it would increase the experienced responsiveness. Therefore, we would like to have it as a primary goal for future plans.

The use of qualitative and quantitative method was adequate for this research and would not be changed for this particular study. With more resources and time we would be

able to do more detailed statistical analysis as well as covering a broader coverage by increasing the sample size.

IX. ACKNOWLEDGEMENT

The authors wishes to acknowledge and thank the users who participated in the study by interviews. A special thanks to Riccardo Scandariato, we are very grateful to him for sharing expertise and valuable guidance to our work and us.

REFERENCES

- [1] P. Di Giovanni, M. Romano, M. Sebillio, G. Tortora, G. Vitiello, T. Gingie, L. De Silva, J. Goontethilaka, G. Wikramanayake, A. Gingie. User centered scenario based approach for developing mobile interfaces for Social Life Networks. In: UsARE 2012, pp. 18-24
- [2] Holtzblatt, K. (2005). "Customer-centered design for mobile applications." *Personal and Ubiquitous Computing* 9(4): 227-237.
- [3] Kangas, E. and T. Kinnunen (2005). "Applying user-centered design to mobile application development." *Communications of the ACM (CACM)* 48(7): 55-59.
- [4] Lee, H. H., Fiore, A. M., & Kim, J. (2006). The role of the technology acceptance model in explaining effects of image interactivity technology on consumer responses. *International Journal of Retail & Distribution Management*, 34, 621-644.
- [5] Venkatesh, V., Morris, M. G., Davis, G. B. & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27, 425-478.
- [6] Sicilia, M., Ruiz, S., and Munera, J. L. (2005). Effects of interactivity in a web site: Themoderating effect of need for cognition. *Journal of Advertising*, 34(3), 31.
- [7] Xu, Q., & Sundar, S. S. (2011, May). Interactivity, arousal and memory: Information processing in an e-commerce site. Paper presented at the 61st annual conference of the International Communication Association, Boston, MA.
- [8] Hinckley, K. (2009). Input technologies and techniques. In A. Sears & J. A. Jacko (Eds.), *Human-computer interaction fundamentals* (pp. 137-152). Boca Raton, FL: CRC Press.
- [9] S. Shyam Sundar, Saraswathi Bellur, Jeeyun Oh, Qian Xu & Haiyan Jia (2014) User Experience of On-Screen Interaction Techniques: An Experimental Investigation of Clicking, Sliding, Zooming, Hovering, Dragging, and Flipping, *Human-Computer Interaction*, 29:2, 109-152, DOI: 10.1080/07370024.2013.789347
- [10] Reeves, B., & Nass, C. (2000). Perceptual bandwidth. *Communications of the ACM*, 43(3), 65-70.
- [11] Nya.boplats.se, (2015). Boplats Göteborg. [online] Available at: <http://www.nya.boplats.se>
- [12] Developer.android.com, (2015). Dashboards | Android Developers. [online] Available at: <https://developer.android.com/about/dashboards/index.html>
- [13] Source code for Android application, Github, (2015). [online] Available at: <https://github.com/DanielHosseini/Android-boplatsen>
- [14] P Wallin, S Larsson, J Fröberg, J Axelsson, "Problems and their mitigation in system and software architecting," *Information and Software Technology*, 2012
- [15] Steven Heim (2007), *The Resonant Interface: HCI Foundations for Interaction Design*, Boston, USA, Addison-Wesley Longman Publishing Co., Inc. ISBN:0321375963
- [16] Hedley, J. (2015). jsoup Java HTML Parser, with best of DOM, CSS, and jquery. [online] Jsoup.org. Available at: <http://jsoup.org/>.
- [17] John W. Creswell, "Research Design - Qualitative, Quantitative, and Mixed Methods Approaches", SAGE Publications, ISBN 9781452226101, 2013
- [18] Bryman, A. and Bell, E. (2007). *Business Research Methods*, 2nd ed., Oxford: Oxford University Press.

- [19] Patton, Michael Quinn (2002), *Qualitative Research & Evaluation Methods*. Thousand Oaks, London, New Delhi: Sage Publications, Inc. ISBN: 9781412972123
- [20] Seaman, CB (1999) *Qualitative Methods in Empirical Studies of Software Engineering*, IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, vol. 25(4), pp. 1-16
- [21] Google Docs, (2015). *Questionnaire_Application.pdf*. [online] Available at: <https://drive.google.com/file/d/0B116eKxtTcmYVnZDaWNla2pLcEk/vi ew?usp=sharing>
- [22] Google Docs, (2015). *Questionnaire_Website.pdf*. [online] Available at: <https://drive.google.com/file/d/0B116eKxtTcmYMDg4d11VZXNUdTg/v iew?pli=1>
- [23] Google Docs, (2015). *User Test Tasks.pdf*. [online] Available at: <https://drive.google.com/file/d/0B116eKxtTcmYa0ZjNjZEQ21QMVE/vi ew?usp=sharing>
- [24] Lehmann, Erich L. (2006). *Nonparametrics: Statistical methods based on ranks*. With the special assistance of H. J. M. D'Abrera (Reprinting of 1988 revision of 1975 Holden-Day ed.). New York: Springer. pp. xvi+463. ISBN 978-0-387-35212-1. MR 395032.
- [25] Corder, G. W.; Foreman, D. I. (2014). *Nonparametric Statistics: A Step-by-Step Approach*. Wiley. ISBN 978-1118840313.
- [26] Socscistatistics.com, (2015). Mann-Whitney U-value calculator. [online] Available at: <http://www.socscistatistics.com/tests/mannwhitney/Default2.aspx>
- [27] Tukey, John W. (1977). *Exploratory Data Analysis*. Pearson. ISBN 978-0201076165.
- [28] Long T. & Johnson M. (2000) Rigour, reliability and validity research. *Clinical Effectiveness in Nursing* 4(1), 30–37.
- [29] Onwuegbuzie, A., & Leech, N. L. (2007). Sampling designs in qualitative research: Making the sampling process more public. *The Qualitative Report*, 12(2), 238-254
- [30] David Collier, "Translating Quantitative Methods for Qualitative Researchers: The Case of Selection Bias," *American Political Science Review* 89 (June 1995)
- [31] Collier, D., & Mahoney, J. (1996). Insights and pitfalls: selection bias in qualitative research. *World Politics*, 49, 56-91.
- [32] Jacob, R. J. K. (1994). New human-computer interaction techniques. In M. D. Brouwer-Janse & T. L. Harrington (Eds.), *Human-machine communication for educational systems design* (pp. 131–138). Berlin, Germany: Springer-Verlag.
- [33] Martin Weik (2006). *Computer Science and Communications Dictionary*. Secaucus: Springer-Verlag New York, Inc. ISBN 978-0792384250
- [34] Connie U Smith (1990). *Performance engineering of software systems*. Boston: Addison-Wesley Longman Publishing Co. ISBN 0201537699