INVESTIGATING THE USAGE OF MOBILE APPLICATIONS VERSUS WEB BROWSERS FOR SMARTPHONES

A MASTER'S THESIS

IN

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BY

SAFA OTHMAN

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Approval of the Graduate School of Natural and Applied Sciences, Atılım University.

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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This is to certify that we have read the thesis **"Investigating Usage of Mobile Applications Versus Web Browsers for Smartphones"** submitted by "**Safa OTHMAN**" and that in our opinion it is fully adequate, in scope and quality, as a thesis for degree of Master of Science.

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ABSTRACT

INVESTIGATING THE USAGE OF MOBILE APPLICATIONS VERSUS WEB BROWSERS FOR SMARTPHONES

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The utilization of mobile applications and services by the smartphone users is ever increasing over the last two decades. A considerable amount of research work has been done in this field with different aims and objectives. The aim of the work done in this thesis is to understand the preferences of smartphone users regarding the usage of the Internet in their devices either by mobile applications or via mobile websites. Our findings will be useful for mobile application developers to understand the main aspects of the average Turkish consumers and what they expect from their mobile usage experience.

The study was conducted in two phases. In the first phase, a survey was conducted with 158 participants from Atilim University, Ankara. In the second phase, interviews were conducted with 30 participants based on testing two implemented applications (a native mobile application and a mobile website). The collected data is analyzed using different statistical methods such as One Way ANOVA.

Obtained results show that mobile applications are mostly preferred, especially for the most common and frequently used applications among users. Moreover, respondents find that mobile applications are better in most aspects. However, we cannot ignore the proportion of participants who make their preferences according to sites.

Keywords: Smartphones, Mobile applications, Mobile websites

ÖZ

AKILLI TELEFONLAR İÇİN MOBİL UYGULAMA VE WEB TARAYICI KULLANIMININ ARAŞTIRILMASI

OTHMAN,Safa

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Doç.Dr. Murat KOYUNCU

Temmuz 2017, 60 sayfa

Mobil uygulama ve hizmetlerinin akıllı telefon kullanıcıları tarafından kullanımı son yirmi yıldır sürekli artış göstermektedir. Farklı amaçlar ve hedefler doğrultusunda bu alanda farklı amaçlarla çalışmalar yapılmıştır. Bu tez kapsamında yapılan çalışmanın amacı; akıllı telefon kullanıcılarının cihazlarında farklı internet erişim ihtiyaçları için mobil uygulama veya mobil web siteleri tercihlerini anlamaya yöneliktir. Bulgularımız mobil uygulama geliştiricilerinin, Türk tüketicisinin ortalama temel özeliklerini ve Türk tüketicisinin mobil kullanım beklentilerini anlamaları bakımından yararlı olacaktır.

Çalışma iki evrede yürütülmüştür. Birinci evrede, Atılım Üniversitesi'nden 158 katılımcı ile bir anket çalışması yapılmıştır. İkinci evrede ise gerçekleştirilmiş iki uygulamanın (bir yerel mobil uygulaması ve bir mobil web sitesi) test edilmesine dayalı 30 katılımcı ile görüşmeler düzenlenmiştir. Toplanmış veri farklı istatiksel metotlar kullanılarak analiz edilmiştir.

Elde edilen sonuçlar; özellikle yaygın ve sık kullanılan uygulamalar açısından mobil uygulamaların daha çok tercih edildiğini göstermiştir. Bunun yanı sıra katılımcılar mobil uygulamaları çoğu yönden daha iyi bulmuşlardır. Yine de tercihini mobil web sitelerden yana yapan katılımcıların oranı da göz ardı edilemeyecek seviyededir.

Anahtar kelimeler: Akıllı telefonlar, mobil uygulamalar, mobil web siteleri

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LIST OF ABBREVIATIONS

API – Application Program Interface

Apps – Applications

CSS – Cascading Style Sheets

GPS – Global Positioning System

HTML5 – Hypertext Markup Language

OS – Operating system

PC – Personal Computer

SDK – software development kit

SPSS – Statistical Package for the Social Sciences

CHAPTER 1

INTRODUCTION

The mobile phone industry has been growing and developing precipitately during the last couple of years. Old mobile devices with limited capabilities are being replaced by new and advanced mobile technology supporting a wide range of mobile services. Smartphones have become more than just a mean of communication; they are considered the most representative type of multimedia systems. The popularity of mobile applications is rising dramatically due to the accelerating rate of adoption of smartphones. In addition, more and more users are accessing the Internet via mobile devices. In 2016, total of 1.397 billion of smartphone units have been sold compared with a total of 245.1 million of PCs and laptops according to Palo Alto [1].

Smartphone users have the potential of using their smartphones in many ways. They download mobile applications from application stores such as Google Play and Apple App Store for various utilizations. These native applications are programs written in specific language for a particular platform or operating system [2]. They are accessed by just clicking a tab on smartphone's desktop and some of them are accessed without an Internet connection and run locally on the mobile device. However, users also attend to use mobile website on their smartphones which are accessed through an Internet browser without the need to download.

Mobile websites are built with web technologies such as HTML5, CSS and JavaScript. They are accessed through a web browser, which presuppose the smartphone needs to be online and connected to the Internet for accessing the mobile web. Mobile websites have a major advantage over native mobile applications, cross-platform compatibility, which making them accessible to the largest audience for the least effort. Any web developer can create a mobile website without specific knowledge about the mobile OS's [3]. Mobile websites are comparatively, easy, cheap, fast to build, despite some device-specific customization is often required.

Moreover, mobile web browsers are reasonably standardized which make it much easier to create a universal mobile web app than a native one [4, 5].

Nevertheless, mobile websites are limited by the browsers sandbox, so they have limited capabilities to interact with the phone itself. This means restricted access to anything non-web. For storage, a web app can use the local storage, as defined in the HTML5 specification [6]. There are also proposals for GPS and camera support directly from the browser. In addition, websites cannot be distributed through an application store, nor will it be available like a native app on the phone. This also reveals that updates to the app are independent of the application store and do not require any update action from the end user [7, 8].

Native mobile applications can leverage the capabilities of the mobile device especially hardware such as camera, GPS and graphics, and software such as calendar, email, contacts, picture/video gallery and file manager. In addition, native applications can be published in app stores and can be discovered by users [9]. App stores remind customers to upgrade apps, so apps that update repeatedly are more frequently brought to the user's attention [10]. However, developing, testing, and porting apps for different environments cost more money compared to web-based applications, especially maintenance and promotion costs are high.

Studies on smartphone user behavior [11, 12, 13] suggest that, there's a lot less time spent on the mobile websites than there is in the world of apps but weirdly, there's more traffic overall [14]. So, the mobile web is about twice bigger in terms of raw traffic, and it is growing faster than the mobile app world [15, 16]. Some sources are showing that just the top 5 apps are responsible for 80% to 90% of all app usage and that users spend at least three hours per day [17, 18] and users download average of zero applications per month [19].

The objective of this research is to investigate the behavior of smartphone end users and find out the most desirable way to use the phone applications, i.e. whether they prefer to use a mobile application or a mobile website. The research on the use of mobile applications and services is thought to be a continuous trend and ever growing over the last two decades [20]. The most common ways to understand user behavior include different kinds of interviews and surveys among smartphone users [21, 26]. In this study, a survey is first conducted with participants from Atilim

University then followed by interviews with different smartphone users categories. The last is set in the form of a questionnaire and based on testing two implemented applications in order to answer the questions which are set in a suitable order to easily input and extract information.

This study reports the first research done on the behavior of Turkish mobile users and seeks to understand the preferences of smartphone users regarding the usage of the Internet in their devices either by mobile applications or via mobile websites. Previous studies [10, 27, 28, 29, 30, 31] focused on comparing the native mobile applications and mobile websites in terms of performance and technologies used for both without measuring or estimating the usage of both applications as our study does. Our findings will be useful for mobile application developers to understand the main aspects of the average Turkish consumer and what they expect from their mobile usage experience.

This thesis is structured as follows. After the introduction chapter, we review related works that have been done in this area in Chapter 2. After that, we describe our research framework and used methods in Chapter 3. Chapter 4 talks about the implementation and interviews. While in Chapter 5 we analyze and discuss the found results. Finally, our findings are concluded in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

Mobile phones together with their applications are developing day after day in rapid manner, thanks to the advances in smartphone technology. Smartphones hold up many applications and services together with the conventional communication services such as music, videos, web browsing, gaming and camera shooting

For that reason, a considerable number of applications are downloaded and installed in the mobiles. The availability of Internet services all over the world and the readiness of the access to it by almost any person have encouraged smartphone users to use the Internet in their phones either by mobile applications or via mobile websites.

This chapter provides a literature review for the outcome of some research works conducted in this area together with a brief background in the evolution and technological developments of mobile phones.

2.1 Early Research work

2.1.1 Mobile Application Usage

The usage of smartphone applications have been assessed by Mia et.al [22] at a South African University. Assessment has focused in social networking applications. They have derived a questionnaire from literature which has been used to assess the intensity and frequency of application usage. They found that the students spend an average of five hours per day on their smartphones. Also, students use Social Networking Site (SNS) tremendously for Facebook chat and Blackberry Messenger (BB users) in order to update their profiles, chat with friends, and look at their friend's profiles and statuses.

Ahmed and Abdullah [23] have made an online questionnaire in 2015 in Bangladesh through social networking using Google form. Their sample number was 1000 people. They have found that the majority of people have been using mobile applications for more than 2 years and only 2% of people have not used them at all. For the type of operating system, they found that 70% use Android and 50% spent more than 3 hours on their smartphones. They also said that around 58% of participants use from 1 to 5 applications in a typical day and 30.4% use from 5 to 10 applications in a day while only 7.5% use from 10 to 20 applications. This means people use quite a large amount of applications in their smartphones regularly.

Xu and Erman [24] have investigated the wide and assorted usage patterns of smartphone apps via network measurements from a national level cellular network provider in the U.S. They found out that applications have similarities in terms of geographic coverage, daily usage patterns, etc. Some applications have a high probability of a common occurrence that is, (i) when a user uses one app, he probably uses another one; or (ii) users use alternatives for the same type of interests, e.g., multiple news apps, bank apps. These opinions suggest that some apps should be treated as a "bundle" when trying to optimize for their user experience. There may be opportunities for integrating these apps.

Bowen [25] conducted a survey to investigate student mobile application preferences. They compared mobile apps and mobile website usage by testing a group of students. Their results showed that in general, most students prefer mobile apps in most of their activities. Also, Gerontini and Moritz [26] provided a large-scale analysis on application usage by collecting data logs from a software client installed on Android smartphones. That software is called Ericsson Apps and is correlated with Open Street Map data sources which offer a general descriptive analysis on mobile usage in terms of time and location.

2.1.2 Native Applications vs. Mobile Websites

A comparison between web applications and native applications has been made by Jobe [27]. The comparison was based on the performance of both applications when using the hardware of the smartphone. The GPS of the smartphone was implemented in both native and web application. He concluded that web applications are being

performed not as good as native applications in case if the hardware is used, however both applications have almost the same performance if no hardware is used.

Madaudo and Scandurra [28] have investigated native and cross-platform applications from different sides and their findings are as follows:

User Experience: Native applications provide a more responsive interface than cross-platform solutions, especially for animations and gesticulation. This is because, when coding with the indented programming language of the platform, you have access to the full device APIs. Though cross-platform solutions offer usage of native APIs which always refers to a limited subset of the device specific features beside that you often have to wait until they are released in order to use them.

Performance: The key advantage of using native development tools is that applications run more smoothly on any mobile devices using that operating system. Instead, the cross-compilation process can sometimes be slower than using native tools for an app. This difference can be easily noted during graphical representations and animations.

Device-specific features: Native tools let developers take full advantages of platform functionality. On the contrary, a cross-platform application serves everyone, but has more limited functionality.

Code reusability: Cross application code is considered reusable. Rather than having to write a specific action or a sequence of actions for each target platform, a cross developer can just write the code once and then reuse it on other platforms or in other projects. This is not always true. Often some cross-platform frameworks use their own subsets of JavaScript, which means that if you want to switch to another platform, that code you wrote before is likely not going to be reusable without refactoring or significant changes [29].

Design challenges: In native development, design is simplified by the support and services provided by the operating system. The operating system can, for example, notify applications about events such as message arrival and power levels. In a cross-platform environment, developers will need to add such features explicitly.

Availability of programming expertise: It is widely acknowledged that there are more Web developers than native developers. Since most cross-platform frameworks are based on HTML5 CSS3, they are easy for web developers to jump in and use alongside the calls to more native functions. On the other hand, due to the low availability, native developer skills usually cost more [10].

Mikkonen and Taivalsaari [30] have argued that the ongoing "Battle of the Decade" between native web apps and HTML5-based open Web applications will determine the future of the software industry and software engineering research. They stated that there are two scenarios for the future of mobile applications and mobile websites. The first one is that native mobile applications will dominate and the second alternative is that open web will dominate.

Charland and LeRoux [31] have also compared native applications with mobile websites in terms of development and user experience. They have also measured the performance of JavaScript using Google's V8 benchmark suite1 and Sun Spider JavaScript benchmark2. They said that performance of web technologies has not yet attained the level of native technologies, but the gap is closing.

2.2 The Evolution of Mobile Phones

2.2.1 Background

The mobile phone recently had its 40th anniversary: On April 3rd, 1973, Motorola employee Martin Cooper made the very first phone call using a handheld mobile phone [63]. Four decades later, from that day, mobile phones have evolved significantly. In particular, two aspects of this evolution can be distinguished as:
(1) Mobile phones have improved in terms of the technology.
(2) Mobile phones have become everywhere in everyday life and around the world. People are more likely to get themselves a new mobile phone as mobile phones offer more functionality and better technology [32]. Accordingly, the more people have a mobile phone the bigger the market grows, and the more likely it becomes that manufacturers of mobile phones will improve their devices to increase their market share (e.g. since people will be more likely to choose the model which has a camera built in); i.e., (2) also leads back to (1). The relation between these two aspects has

led to the evolution that finally resulted in the ecosystem of mobile phones as we know it today [33].

2.2.2. Technological Development

Martin Cooper's invention became available as the Motorola Dyna TAC in 1983, 10 years after the first call was made using Motorola's prototype. The device, shown in Figure 2.1(a), was commonly referred to as the "brick" device due to its form factor, which had to contain 30 electronic circuit boards [34]. The first mobile phone referred to as fitting into a pocket became available in 1986: the Technophone EXCELL PC105T [35]. This fact was the unique selling point for advertising this model, as Figure 2.1(b) shows. The miniaturization of electronic parts is an ongoing trend mainly supported by Moore's Law, as is the reduction of the devices' weight. Nowadays, the size of a mobile phone is mainly determined by the dimensions of its battery and the display; while the latter cover nearly half of current devices' surfaces as can be seen in Figure 2.1, which shows a comparison between the first mobile phone that was commercially available and one of the latest models of the same company. While the displays on the first cellular phones were tiny, the displays on latest generation phones cover nearly the whole front face of the device. This is also leveraged by the fact that today's displays are touch-reactive and can be used as input devices, e.g. to implement buttons for keyboards [36].

The IBM Simon, which became available in 1994, was the first cellular phone that was referred to as a smartphone. The device, shown in Figure 2.1(c), already provided many features that we would expect from a modern smartphone, including an address book, calendar, appointment scheduler, calculator, world time clock, electronic note pad, handwritten annotations and standard and predictive stylus input screen keyboards [37].

Another important technical milestone in the evolution of mobile phones to smartphones as we know them today was the possibility for third party software developers to program their own applications for mobile devices. While at first only the device manufacturers and network carriers were able to add new functionality to devices, now outside developers could also provide software for mobile phones [38].

(a) DynaTAC **(b)**ExcellPocketphone **(c)** IBM Simon **(d)**RAZRi

Figure 2.1: Milestones of the mobile phone evolution: (a) Motorola DynaTAC was the first mobile handheld phone commercially available, (b) an advertisement of the first mobile phone that would fit into a pocket, (c) the IBM Simon as first mobile phone that was referred to as a smartphone, and (d) the Motorola RAZRi as a representative of the current generation of smartphones.

For a long time a special derivate of the Java Platform, the Micro Edition, was the major technology for building software for mobile devices. This derivate was especially designed for embedded systems such as mobile devices. It was introduced in 1999 and was also known as Java Platform 2 Micro Edition (J2ME). The J2ME platform provided standardized APIs for access to core functionalities like storage and web access, to multimedia features of devices, and to sensors like these for GPS location and acceleration [39].

2.2.2 Ubiquitous Spread

Mobile phones have made an enormous leap from the hand of one single person in 1973 to the hands of billions of people worldwide today. In 2016 more than 7.4 billion mobile cellular phone subscriptions have been existing as reported by the ITU [40]. This enormous spread shows the steadily increasing number of worldwide mobile phone users. According to a recent report of the Pew Research Center on smartphone ownership, currently about 91% of the US population owns a mobile phone, an increase from 83% in 2011; of those, the proportion using smartphones increased from 35% in 2011 to 56% in 2013. In fact, Bell and Dourish [41] in 2007

already argued that mobile phones at that time already ubiquitous computing devices with capabilities for supporting users during everyday life are a fruition of Weiser's [42] vision of ubiquitous computing.

By looking into the numbers of people who start using specific services on their mobile phone, we can infer that the time people spent on their devices daily is also increasing, as the devices assists them with an increasing variety of applications. For instance, the share of cell phone owners using their devices to check their bank accounts increased from 22% in 2011 to 43% in 2015 ; using the device for recording videos increased from 18% in 2007 to 44% in 2015 [43]. In fact, the time people spend with applications on their phones these days comes close to the time people spend watching television [48].

The proliferation of mobile phones also had an impact on personal and interpersonal social aspects, resulting from the mobile phones' ubiquitous spread and pervading of daily life. They became an inherent part of their owners' daily life, as discussed by Want [50]. In fact, compared to previous generations of phones, people are more likely to keep smartphones in the same room, and take less care that their smartphone use will disrupt other people [49]. Researchers also recognize the disorder of people depending on their mobile phones, called Nomophobia. And interestingly, the possibility of incessantly being able to check dynamically changing content, like updates from online social networks, has been found to be habit forming [42].

The spread of mobile phones over the whole world, and the large number of people using mobile phones on a daily basis, emphasizes the urgency of the line of research conducted in this thesis: gaining a better understanding of how people use their devices will allow us to improve the support for this vast group of users in making more efficient use of their devices.

2.2.3 Application Stores History

As already briefly mentioned, the invention of a platform for the distribution of mobile software was a technical invention, which made it easy, inexpensive and fast to download programs to a user's own mobile phone [43]. The most influential of

such mobile application platforms was the AppStore release by Apple in 2008 for the iPhone, which was the first of its kind.

As described, mobile phones have evolved from single- to multi-purpose devices, and today there exist a huge number and great variety of functional add-ons that support users in different activities, e.g. banking, navigating, playing games, taking notes, or sightseeing. The most interesting phenomenon of such application stores is that people can now easily alter the purpose of their devices by adding new functionalities, so called apps [44].

This functional customization is supported by application stores like Apple's AppStore or Google Play Market. They provide new means for software providers to develop market and distribute their applications, and for end-users such platforms provide a convenient way to access applications since the end-users do not have to handle any technical details [45]. While the customization of a phone's look and feel and audio profiles was a very important feature of first mobile phones, being able to also customize phone's functionality in terms of applications also became increasingly important. As such, the most important aspect of application stores that we will focus on in this work is that the end-user himself is able to customize the functionality of his device. Due to the variety of services available on application stores, e.g. recreational applications and spiritual applications, mobile phones were integrated even deeper into people's lives [46].

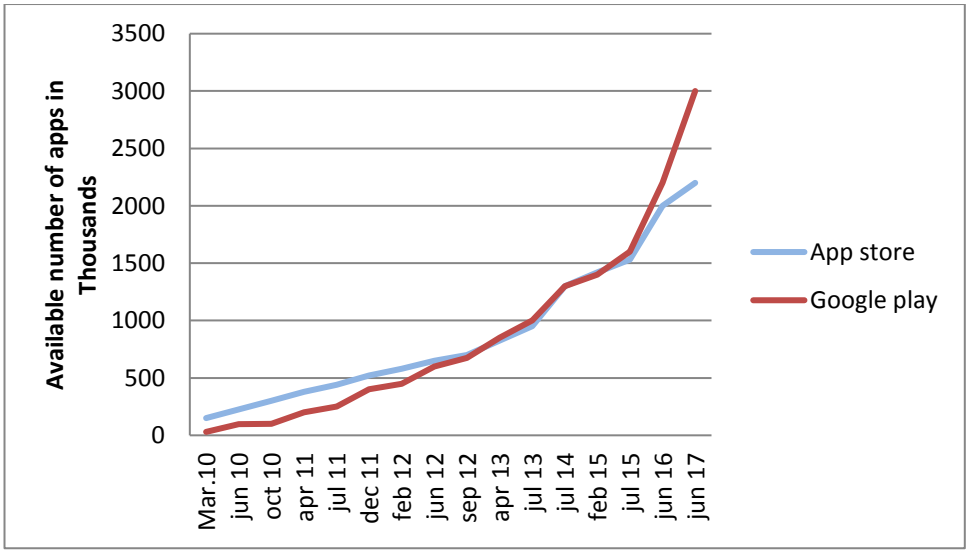

Figure 2.2: Number of applications available per application stores between June 2010 and June 2017 [65, 66]

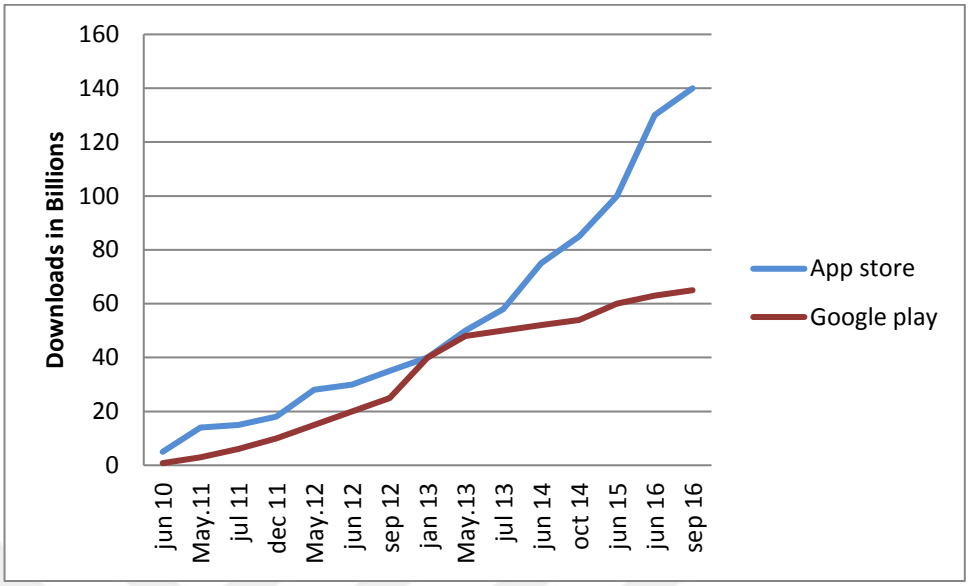

Figure 2.3: Cumulative number of downloads of applications from stores between June 2010 and September 2016 [67]

Resulting from the popularity of mobile application stores, the number of available applications is steadily increasing. At time of writing this thesis there were more than 2,200,000 applications available for Apple's iPhone and more than 2,900,000 applications for the Android platform. One can expect these numbers to be outdated soon, and therefore Figure 2.2 [65, 66] shows the recent growth trend of mobile applications stores, based on which a further increase can be anticipated. The number of application downloads, i.e., the number of times people installed applications on their phones surpassed 81.4 billion in 2013 [47]. Figure 2.3 shows the increasing number of applications that users have downloaded from the application stores [67].

CHAPTER 3

RESEARCH METHODOLOGY

This chapter introduces the research methods used in our study. In this part, we describe our research framework, data collection, survey methods.

3.1 Research Framework

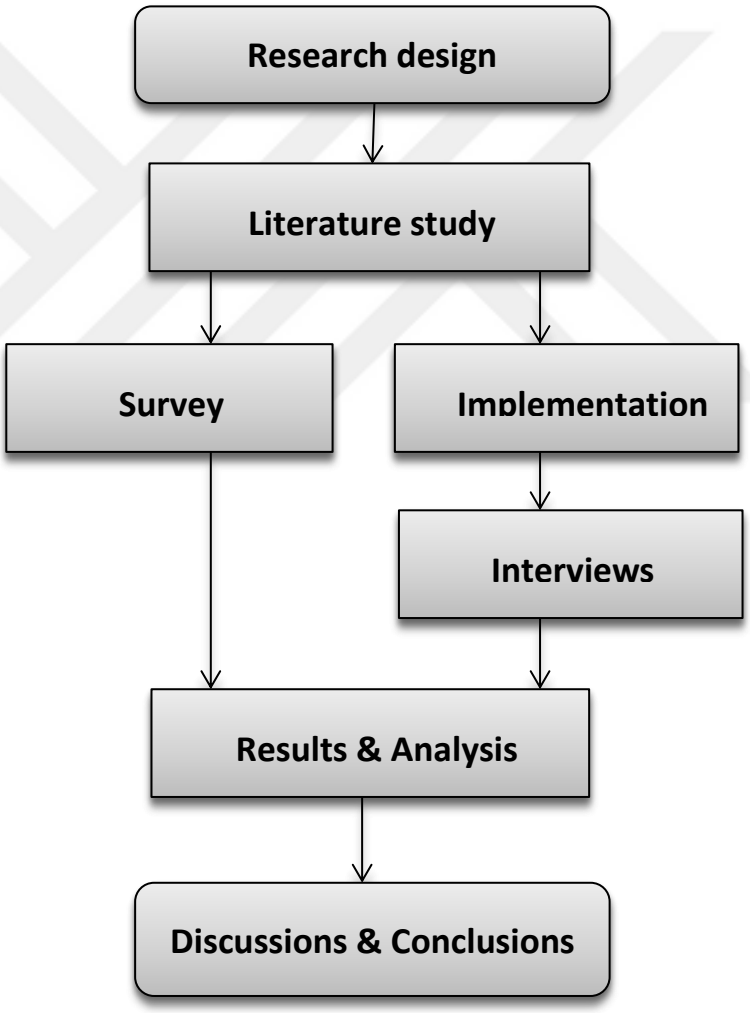

Figure 3.1: Research framework

Figure 3.1 illustrates our research framework for this study. As shown the framework starts with the research design which represents the early stage of the research followed by literature study. After that, two steps operate simultaneously; one of them is a survey and the other one is implementation and interviews. Then, results are collected and analysed. In the last stage, obtained results are discussed and derived conclusions are shared. The steps of the research framework are described as:

Research design: represents the early phase of the research, where the problem area is fixed, research questions are determined and different research designs are evaluated to find the most appropriate one for our study. Our research questions are based on investigating the usage of mobile applications versus web browsers for smartphones. Methods used in this work will be conducting a survey and interviews based on testing two implemented applications.

Literature study: helps to develop a right understanding of a theoretical background made in the area and earlier researches. The importance of literature study is represented in providing a comprehensive thought about the purpose and expectations for research to put appropriate focus in the analysis. Also, it enables to mark off the area and narrow down the research problem. In our work several papers related to comparing between mobile applications and mobile websites and papers that talk about smartphone user behavior were collected and summarized. Later in conclusions results from these studies are compared with our results.

Survey: acts as an argument of authority. In other words, the most popular and reliable way to collect data and information about a topic is conducting a survey. Surveys are a common mean to reach a certain community in order to get real feedback from participants. In our thesis, we conduct a survey to collect data about our topic which is user preferences on mobile phones. We will talk in details about our survey later in this chapter.

Implementations: Two applications are implemented; one is a native mobile application using Android studio and the other one is a mobile website using HTML5 (will be discussed in Chapter 4).

Interviews: Interviewing is an effective data collection method of soliciting and documenting an individual's or group's perspectives, opinions, values and attitude about their personal experiences and social worlds. In our study, we use interviews to evaluate the two implemented applications in order to answer the research questions. Thirty participants were interviewed. First, they were asked to test the applications. After that, participants were asked some questions and the answers were collected and organized for analysis (will be discussed in Chapter 4 and Chapter5).

Results and analysis: Data analysis is a process used to inspect, clean, transform and remodel data with a view to reach to a certain conclusion for a given situation. Data analysis also helps in structuring the findings from different sources of data. In this thesis, data from the survey and the interviews was analysed separately and compared using PSPP (a free alternative to the propriety statistics program SPSS) to assess the research questions. For feasible and meaningful analysis and to analyse the differences between responses from different subgroups, several statistical methods and tests have been used in this study like ANOVA test and T-Test (will be discussed in Chapter 5).

3.2 Survey

The most common technique used to gain information about a topic is conducting a questionnaire-based survey. In this thesis, a survey is conducted to collect data about user preferences on mobile devices.

3.2.1 Data Collection

A survey was applied to both students and faculty members at Atilim University in Ankara from 7th to 26th of October, 2016. The tool that has been chosen to collect data is a self-administrated questionnaire. The questionnaire was prepared according to known standards and has been pre-tested by some faculty members and some students before distribution. Then, according to the feedbacks of the tested group, it was finalized and its hard copies were distributed to the students and faculty members. They were asked to fill the questionnaire and they read the instructions on

their own. For students, their responses were immediately collected such that they had filled the questionnaire in classrooms with the help of instructors, and the number of respondents was 153. Since the number of respondents from the faculty members was less than the required, a soft copy of the questionnaire has been prepared using Google forms and sent by e-mail to the instructors of the university, and finally, we have reached to 32 respondents. The data from both the online survey and paper survey was collected and gathered in the Microsoft Excel spread sheet and imported into PSPP for analysis.

3.2.2 Questionnaire Design

The questionnaire had to be structured so that students and faculty members could answer the questions immediately. In other words, questions had to be clear, straightforward and understandable. It is also important to make sure that the potential response to the questions will give the required information. The questionnaire was kept as short as possible so that the participants will not be frightened and refuse to answer or complete the survey.

3.2.3 Pilot Testing

The questionnaire was pilot-tested before distribution to participants. About 15 questionnaires were distributed to friends, colleagues and faculty members. The purpose of the pilot test is to verify the feasibility and improve the questionnaire in order to uncover flaws and potential causes of confusion, such as misguiding questions that could potentially result in invalid responses. Pilot test is a pretesting of a questionnaire before disseminating to public to make sure that questions have logic, feasible and is direct related to the wanted data of the research. It also helps to verify that, people understand the questions in the same way which leads to reliability and truthiness of data resulted from that survey or questionnaire. Our test was done as follow:

1. Questionnaires were distributed to close friends, colleagues and specialists. According to their feedback some modifications were done.
2. After that more questionnaires were distributed to other friends and colleagues and their response and feedback helped to set up the final version.

3. As result, the description of the survey was modified to be clearer. The questions were reduced from 21 questions to 18, and some changes to the question's title were made as well. Also, some changes have been made to the choices of the questions.

3.2.4 Establishment of the Questions

Each following subsection focuses on a question for this study and explains the nature of the investigation. This survey comprises eighteen questions.

Questions about demographic information

Demographic questions are an important aspect of any survey. Demographic questions help to find what factors may influence a respondent's answers, interests, and opinions. Collecting demographic information enables to cross-tabulate and compare subgroups to see how responses vary between these groups. The questions were about age, gender and education level.

Which operating system does your smartphone use?

This question aims to find out which operating system is commonly used. The choices were Android, Apple, BlacBerry or Not sure.

How much time in a day do you use the Internet on mobile device or tablet?

Here we want to know the average time that users spend using the Internet on their smartphones, and answer options are less than 30 minutes, 1-3 hours, 3-5 hours or more than 5 hours.

How do you find your-self as a smartphone user?

This question shows how participants find themselves as smartphone users whether they are experts, advanced users, intermediate users or beginners? The purpose of this question is to see if the users experience has an obvious effect on their behaviour on the smartphone or not.

What is your primary purpose for using Internet on your mobile phone?

In this question, participants were asked about the top applications they use on their smartphones, (Games, Email, Music/Videos, Social media (For example Facebook), News/Newspaper, Shopping/Booking, Finance/Banking, weather, Books (For example, Amazon Kindle)). The responses of this question will give an idea about what people interested in when using the Internet on their smartphones and what are their favourite applications.

Which browser do you prefer on your smart phone?

Users were asked which Internet browser they prefer to use. Do they use Google Chrome, Firefox, Opera mini, Yandex, Internet explorer mobile or Safari?

About how many apps do you currently have/did you install on your smart phone?

On a typical day, how many of those apps do you use?

The aim of these two questions is to find out the average number of applications that users have downloaded and the average number of applications that they really use in their normal days. The answer to these two questions will illustrate where users spend their time.

Specify your access preference for the following type of applications (Mobile apps or web browser)

- Games
- E-Mail
- Music/Videos
- News/Newspaper
- Social media (For example Facebook)
- Shopping
- Finance/Banking
- Weather
- Books (For example, Amazon Kindle)

In this question, participants were asked to select between mobile application and web browser when they access their applications. For example, if someone wants to open Facebook on his smartphone, does he use a Facebook application that he had downloaded or use one of the browsers on his smartphone? Another example, if

someone wants to do an online shopping, does he download applications of the online shops or just search them on an Internet browser?

In general, what do you prefer to use when using Internet on your smartphone?

This is a general question about the general user preference (Web browsers, Mobile Application, Depends on the site, No preference).

If your answer was web browser, why do you use more web browsers rather than applications?

The aim of this question is to understand why participants may prefer using mobile applications rather than mobile web sites. The given options are as follows:

a) More used to it (from experience with computers).

b) Because the application related to the website I want to visit doesn't exist or I can't find it.

c) I don't want to install applications for random use.

d) The applications from some websites are not functional, don't work well.

e) Usually, I search for a general term, rather than needing a specific application.

If your answer was mobile application, why do you use more applications rather than web browsers?

The aim of this question is to understand why participants may prefer using of mobile websites rather than mobile applications. The options for answer are as follows:

a) Better use, tailored to mobile phone.

b) It is faster (Internet Speed).

c) It is easier to find, straight on my main screen, application list.

CHAPTER 4

IMPLEMENTATION

4.1. Introduction

As discussed in previous chapters, our study aims to find out what the user prefers when using the Internet on smartphones and tablets. In chapter 3, we explained how we conduct a survey to collect data about our topic. For more feasible and supportable results; two survey applications are developed (a native mobile application and a mobile website) and tested by a group of participants for interviews. In this chapter, we discuss the development tools of each application, application design, user interface, evaluating and testing and the interviews.

4.2. Native Mobile Application

4.2.1. Development Tools

4.2.1.1. Android Studio

Android is an open-source platform and operating system for mobile devices. It was found by Open Handset Alliance which is an association of many high technology companies, directed by Google and designed mostly for touch screen mobile phones, such as smart phones and tablet computers. Android platform is a complete software stack and operating system that is based on free Linux kernel. It involves several layers, including low level libraries, application framework and Android Runtime. The low-level libraries of Linux kernel are native libraries which are written in C/C++. End user applications are written in Java and they use the application framework. Figure 4.1 illustrates the Android structure [51].

Linux Kernel: Linux version 2.6 provides the basic services for Android services such as security system, memory management, process management, network stack

and hardware drivers. The kernel also provides an abstraction layer between hardware and the rest of the software stack.

Runtime Android: The runtime allows Android to be more than a mobile Linux implementation. The base libraries that Android includes provide most of the features available in the libraries of the Java language base. The Android application runs its own process, with its own model of the Dalvik Virtual Machine (DVM)

- **Core Libraries** –most of the functionality available in the core Java libraries is provided by core libraries, as well as the Android specific libraries.
- **Dalvik VM** – is virtual machine that has been optimized to ensure that a device can run multiple instances efficiently [52].

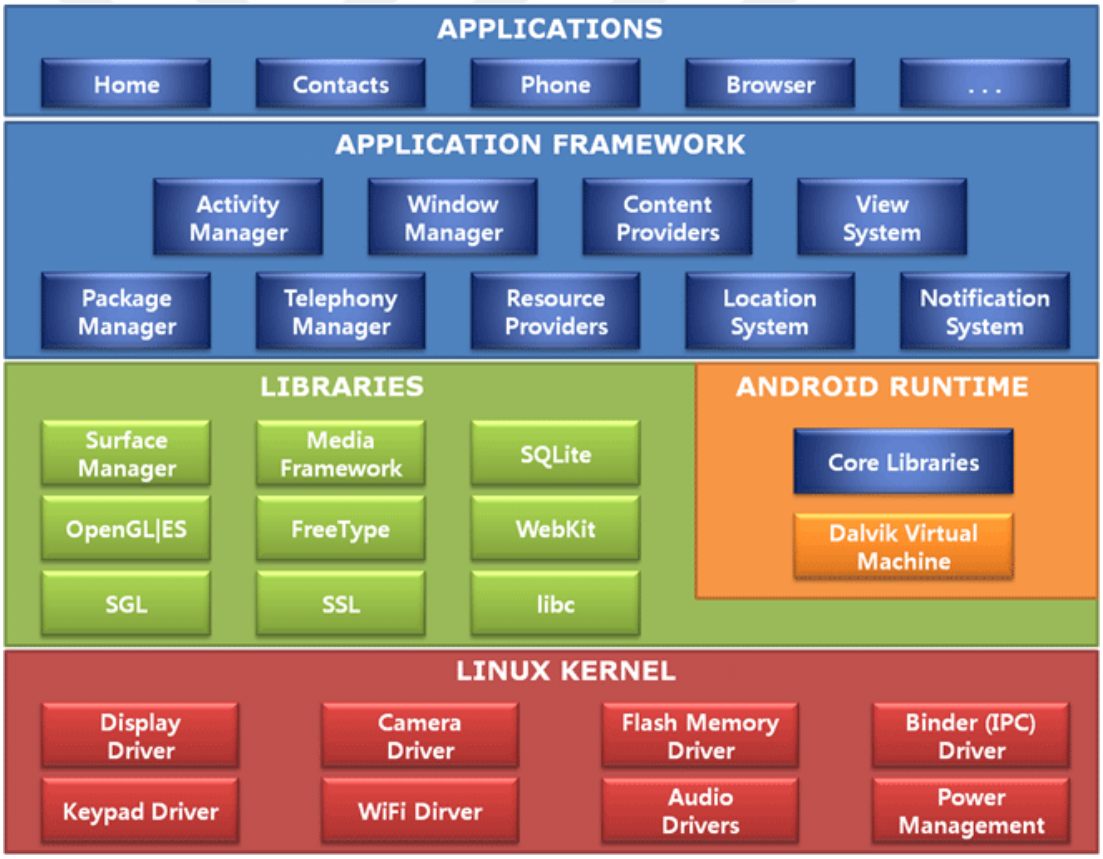

Figure 4.1: Android structure.

Libraries: Android consists of a set of libraries. C / C++ is used by various components of the Android system. These features are open to developers through the Android application framework. The core libraries are the following:

- **Surface manager** – provides display management
- **Media Framework** – A library for playback of audio and video media
- **SQLite** – provides database support
- **OpenGL | ES** – graphics libraries for 2D and 3D graphics
- **FreeType** – provides font-related operations support
- **WebKit** – integrated web browser and Internet security
- **SGL** – graphics libraries
- **SSL –** provides Internet and web browser security
- **libc –** supports for Android-specific services such as system properties and logging

Application Framework: All developers have full access to the same framework APIs used by applications base. The reuse of components is simple and any application can publish its capabilities and any other application can then make use of those capabilities.

Applications: All applications are built on the application layer by the same API libraries. The application layer runs within the Android runtime, using classes and services made available by the application framework. As Android is a multitasking platform, it can simultaneously run more than one application without one affecting the performance of the other. Android is an open source platform and thus it allows device manufacturers or third-party developers to modify it. This ensures that it evolves, continuously progresses and keeps pace with the latest technologies and developments [59].

4.2.1.2. Android SDK

The applications developed by third-party developers have no difference from the existing device's applications. They might as well have access to all the main features of the device, which allows users to fully enjoy its potential. For example, users can use applications to display songs or videos that are stored on their device.

The development of applications is not limited to the above, but an application can have access to the web, to transmit data between the device and the web and display them on the device's screen [53].

Google's Android Software Development Kit (SDK) and the use of the Java programming language are necessary to the development of an Android application. The Android SDK includes everything needed to develop, test and debug an Android application. A description of the included components is listed below [54]:

- **Android APIs:** They consist of the core of SDK and they provide access to the Android stack.

- **Development Tools:** SDK includes tools that let a programmer compile, run, and debug applications.

- **Android Emulator:** It is a full interactive Android device emulator. Running the applications on the emulator is the same as running them on a real Android device. It also provides different interfaces and options to run the application on a specific device emulator or with custom hardware features (RAM, CPU, and Resolution).

- **Sample Code:** SDK includes a selection of sample applications to help understand some fundamental Android APIs and coding practices. Each version of the Android platform available by the SDK Manager [55] offers its own set of sample apps.

4.2.2. Application Design

The application is a survey application that allows user to fill up a questionnaire. After the user submits the data, it will be stored in a database built in the application. Also, the time taken by the user to fill the survey is recorded and stored in the database as well. Figure 4.2 shows the use case diagram of the application.

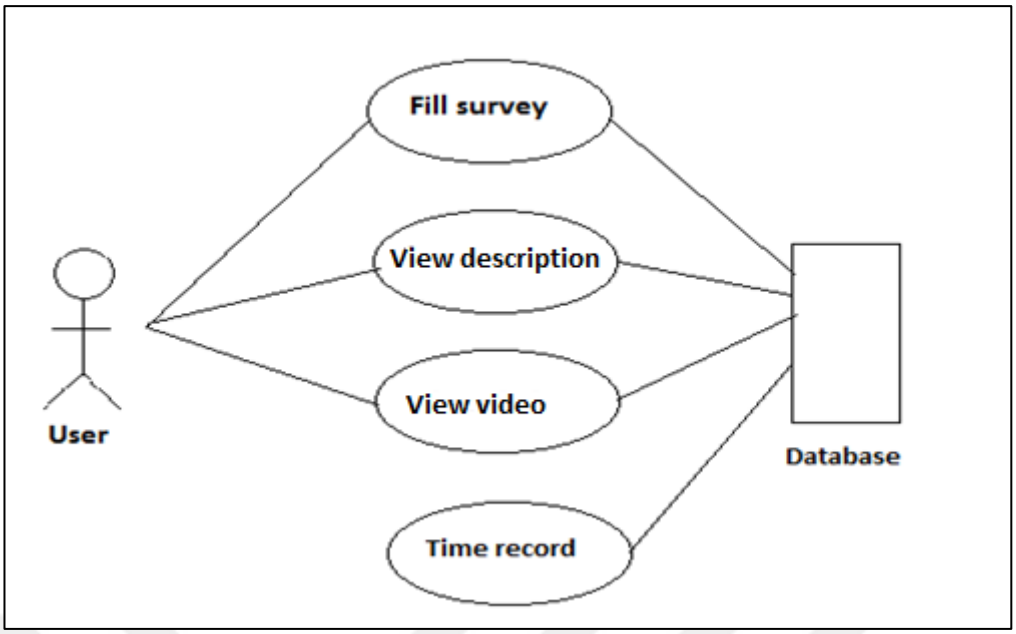

Figure 4.2: Use case diagram

4.2.3. Class Diagram

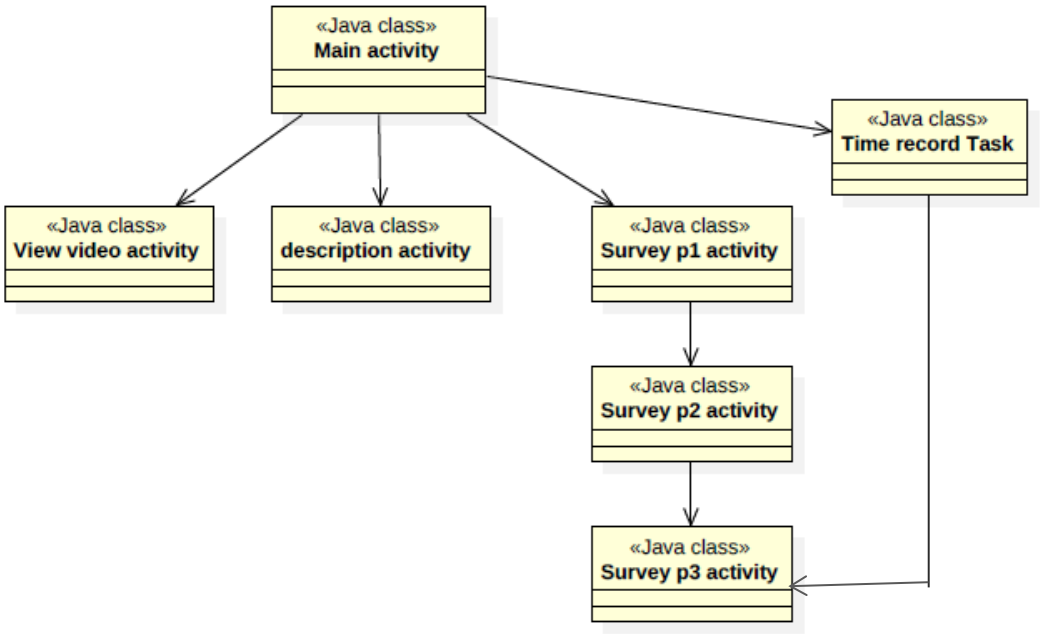

Figure 4.3: Class diagram

Figure 4.3 presents the main classes of the application. Every class with suffix activity represents a screen of the mobile application. For example, MainActivity.class represents the home screen of the application. While the class

with suffix task like TimeRecord.class is a class refereed to SQLite is not presented in the diagram because each one of the other classes has dependencies (arrows) on them and thus the diagram is not easily readable. An extended diagram with SQLite classes is available in Appendix C.

4.2.4. User Interface

The user interface is designed in such a way to provide a friendly environment to the user. Each window in the application uses either Linear Layout or Relative Layout wrapped by ScrollView to support all orientations and provide scrolling for various screen sizes. Figure 4.4 shows the questionnaire window in both orientations. Each window of the application has navigations to other windows using control methods like buttons. For example, the home screen window consists of three tabs; one tab takes the user to the questionnaire; another one shows the user a description and instructions about the survey and the last one shows a video as a more illustration about the purpose of the survey. Figure 4.5 shows the application's navigation and controls.

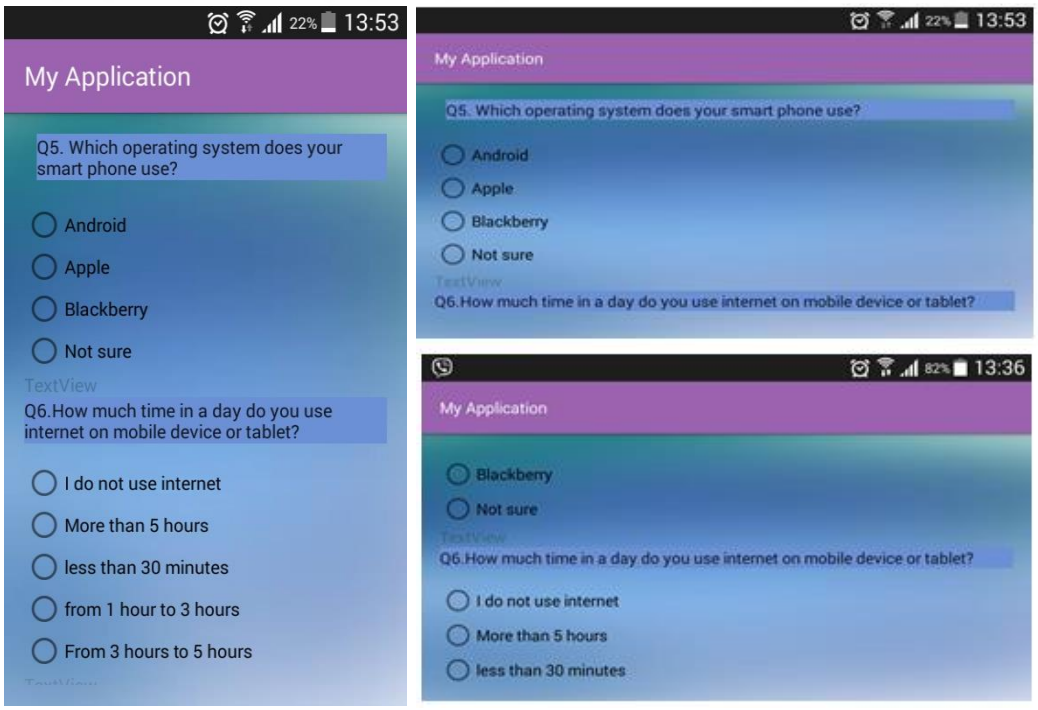

Figure 4.4: Questionnaire window in both orientations.

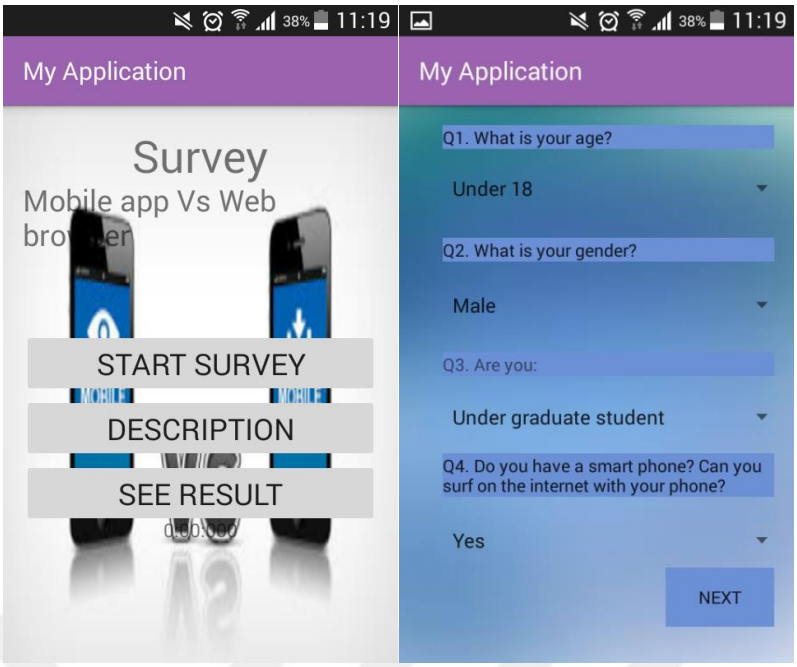

Figure 4.5: Application's navigation and controls

The application uses different input methods like Spinners, RadioButtons, CheckBoxes. Figure 4.6 shows the application's input methods.

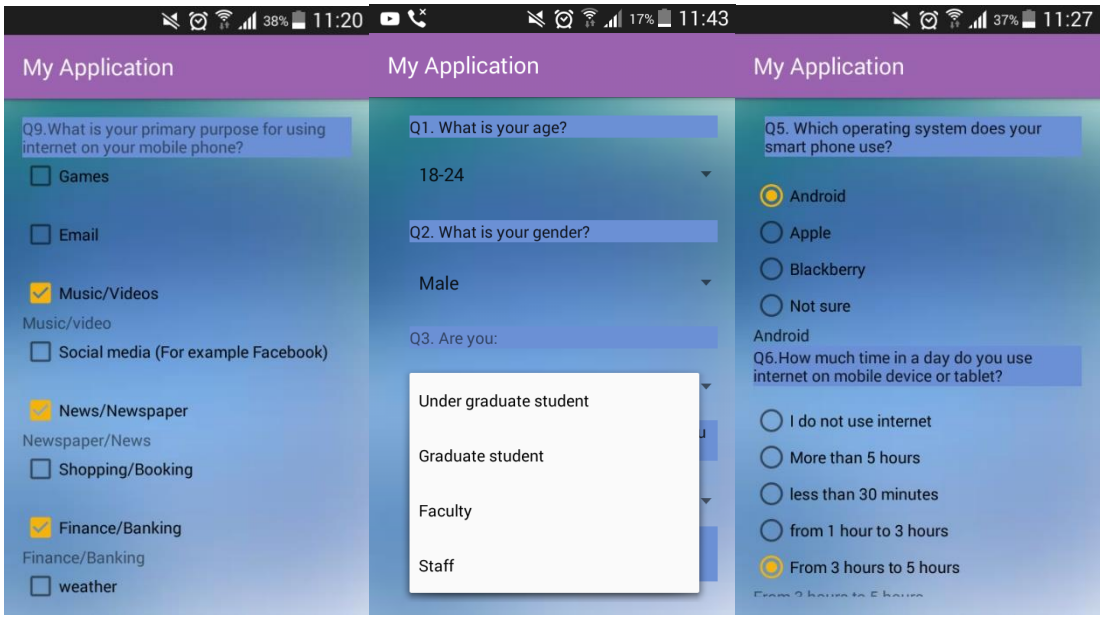

Figure 4.6: Application's input methods

4.2.5. Database

The application uses SQLite database, which is built in the Android Studio. SQLite supports all standard relational database features like querying. The data entered by the user and the time taken by each user are stored in the database.

4.3. Mobile Website

4.3.1. Development Tools

4.3.1.1. HTML5

HTML5 is the fifth version of the HTML standard [56]. As its predecessors, HTML5 is a markup language for describing and structuring the web pages. The new features of HTML5 turn the web to a highly potential application platform. In contrast to proprietary web technologies such as Adobe Flash or Microsoft Silverlight, HTML5 is an open standard and will eventually be natively supported by the most web browsers without external plugins.

The new features of HTML5 include both new syntactical features such as video and canvas elements and also APIs (Application Programming Interfaces) which can be called with JavaScript. These APIs include immediate mode 2D drawing on canvas elements as well as timer-based callbacks and offline applications with the application cache [57].

4.3.1.2 CSS

CSS is the language for describing the presentation of Web pages, including colors, layout, and fonts. It allows one to adapt the presentation to different types of devices, such as large screens, small screens, or printers. CSS is independent of HTML and can be used with any XML-based markup language. The separation of HTML from CSS makes it easier to maintain sites, share style sheets across pages, and tailor pages to different environments. This is referred to as the separation of structure (or: content) from presentation [58].

4.3.2. Mobile Website Design

The mobile website consists of three pages. The questionnaire is divided into three parts; each part is presented in a page. The starting point is the home page, and from the home page, the user can access the second page, then from the second page to the third one.

4.3.3. User Interface

Each page consists of a part of the questionnaire and some images and videos for more illustration about the purpose and substance of the survey. Figures 4.7 and 4.8 show the website user interface.

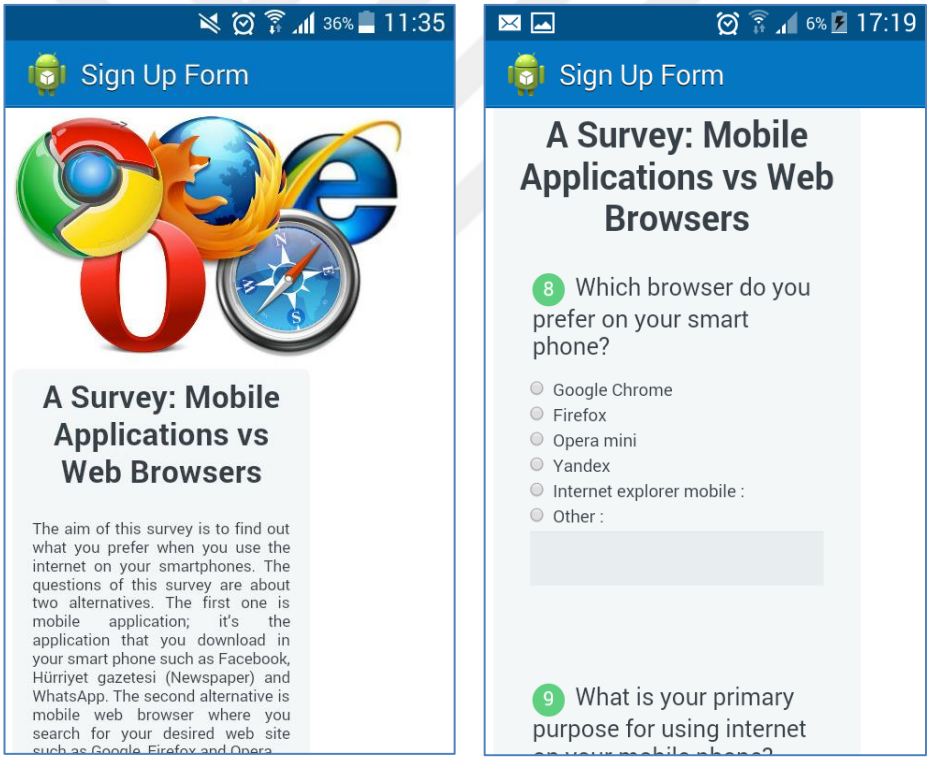

Figure 4.7: Website user interface.

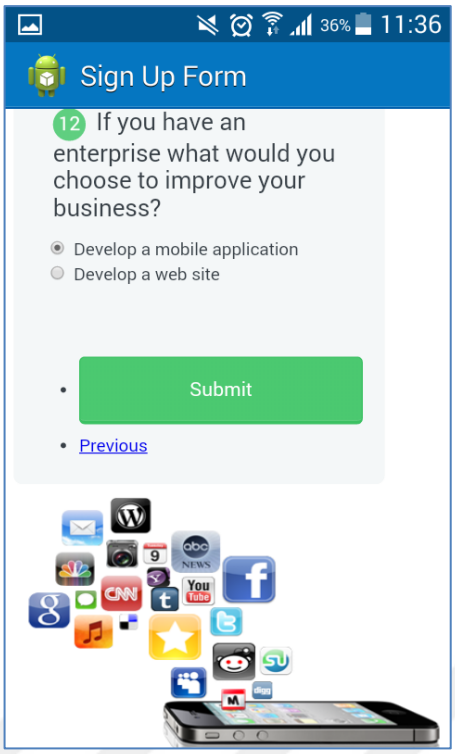

Figure 4.8: Website user interface

4.4. Evaluating and Testing

The native mobile application was tested on Android virtual device before it was downloaded on a Samsung Galaxy S4. The mobile website was also downloaded on the same smartphone. After that, thirty users have tested both applications to compare between them and gave their feedback. User feedback and results will be analyzed and discussed in Chapter 5.

4.4.1 Interviews

The interviews are based on testing the implemented applications. The interview questions are based on comparing both applications and they are inspired from the survey questions. The idea is to compare the survey results with the interviews results. The questions are divided into two parts; the first part consists of general questions about where people use both native and website applications, while the second part consists of specific questions about the two implemented applications. Appendix B provides a detailed list of interview questions.

CHAPTER 5

RESULTS and ANALYSIS

5.1. Introduction

This chapter is devoted to analyzing the data collected through the methods described in Chapter 3 and Chapter 4. This chapter consists of three parts; the first part describes the descriptive statistics of our data and the second part explains the analysis and the discussions. The third part describes the results from interviews and the comparison between the survey and interviews results.

5.2. Data Analysis of Survey

5.2.1. Descriptive Statistics

The number of respondents that took part in our survey was 165, but 158 of them have fully and correctly answered all the questions. Demographic data was generated from the first three questions; age (Q1), gender (Q2), Graduation level (Q3). The participants are split into three age groups; 43% of participants are aged between 18-25, 21% are aged between 26-30 and 36% are aged above 30, as shown in Figure 5.1. Participants are also split into three graduation level groups; 51% are undergraduate students, 30% are graduate students and 19% are faculty members, as shown in Figure 5.2.

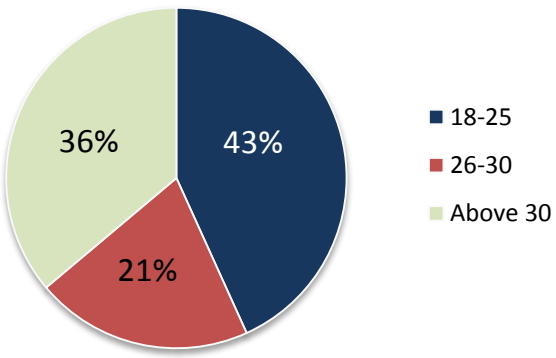

Figure 5.1: Age scal

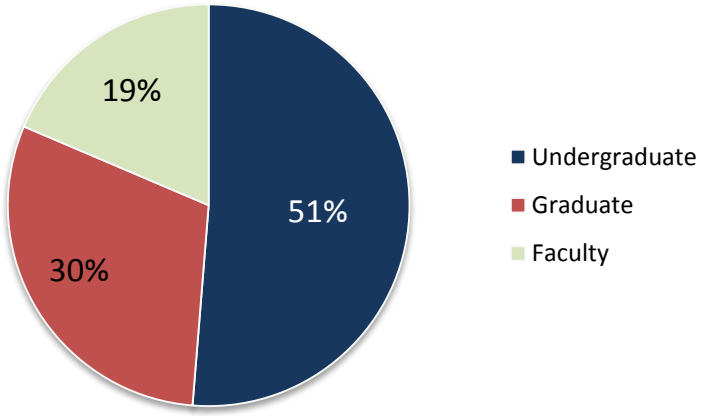

Figure 5.2: Graduation level scale

Participant's device ownership was significantly focused on two smartphone platforms; Android and Apple (iPhone) which together represent 95% of the survey responses, Apple (iPhone) 32% compared to Android 63%. Figure 5.3 shows percentage of response per platform.

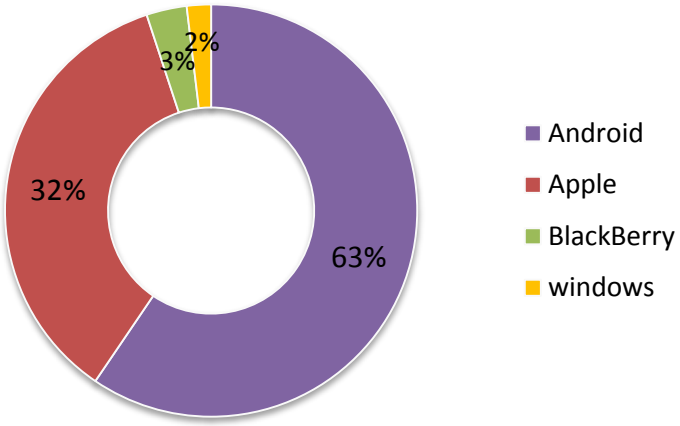

Figure 5.3: Platform scale

NetMarketShare report [62] says that 65% of owners have Android and 31% owns iPhones (Apple) around the world, while a study in Bangladesh [23] have found that 70% of owners have Android and only 14% have Apple devices. In Germany 67% have Android and 30% have Apple [60]. Figure 5.4 shows a comparison between our results and previous studies results.

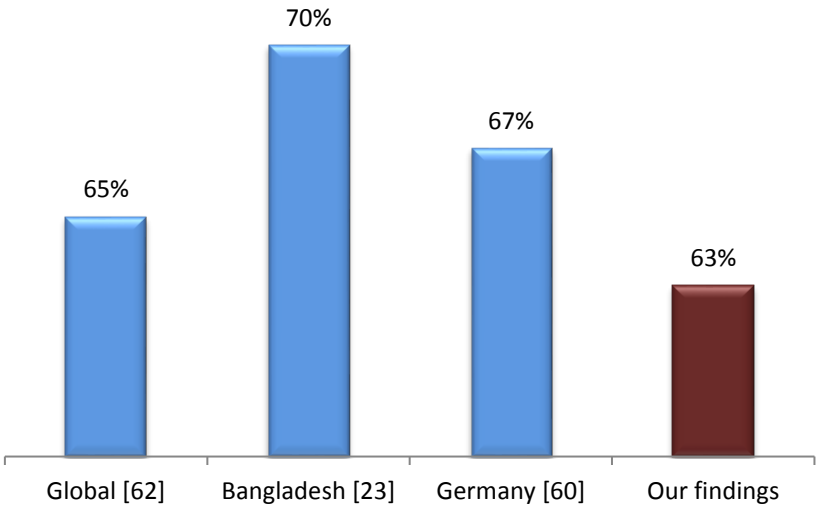

Figure: 5.4: A comparison between studies in terms of Android owners

We found that 41% of participants spend from 1 to 3 hours daily using the Internet on their smartphones while only 14% of them spend more than five hours. Figure 5.5 shows the percentage of respondents according to their time spent on smartphones. According to Digital Trends report [64] and Smart Insight report [68], the average time spent by users is 4.6 hours which is different from the result we got where our result indicates that the average time spent by users is from 1 to 3 hours. Figure 5.6 shows the time spent on smartphones among different studies [23, 22].

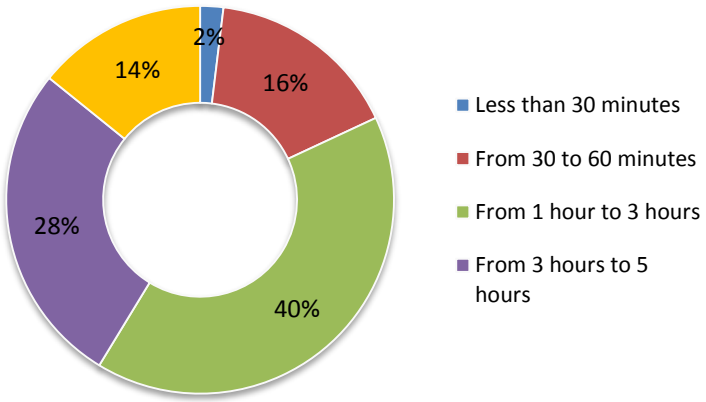

Figure 5.5: Time spent on smartphones

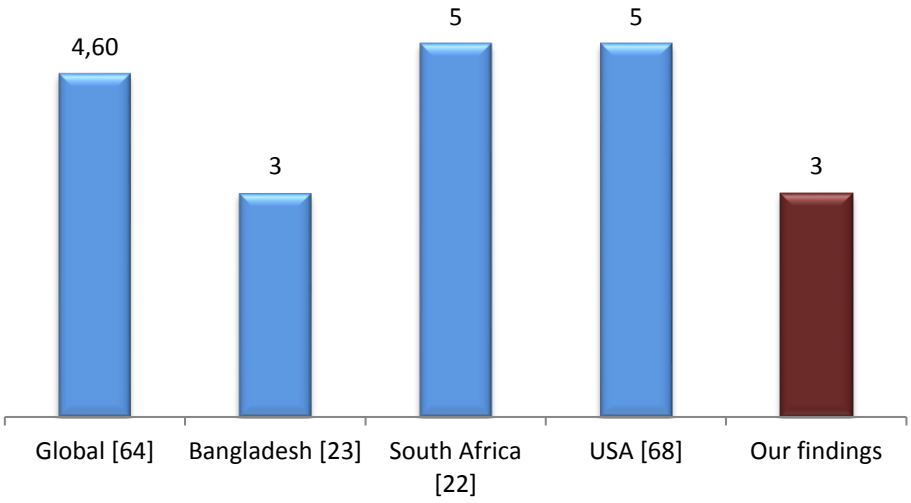

Figure 5.6: A comparison between studies in terms of average time spent on smartphones in hours

Participants were asked to categorize their level of experience as smartphone users. 75% of participants identify themselves as either intermediate or advanced users as shown in the figure below. 30% of participants who aged from 18 to 25 find themselves expert users while only 10% of participants aged above 30 find themselves expert users.

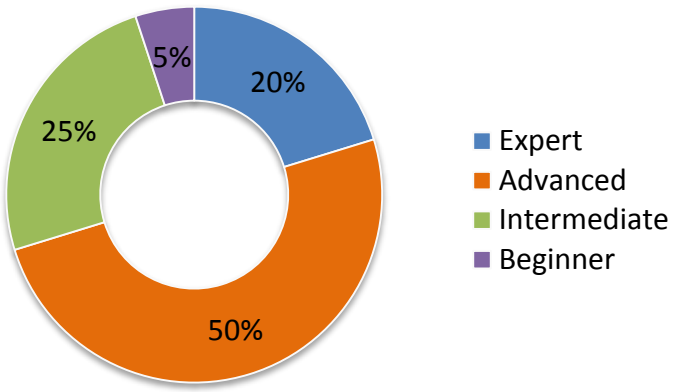

Figure 5.7: Level of smartphone usage

For a list of 9 categories of mobile device functionality, participants showed their most purposes for using the Internet on smartphones. The most two preferred categories are social media and E-mail while the least ones are books and games. Figure 5.8 shows most preferred applications.

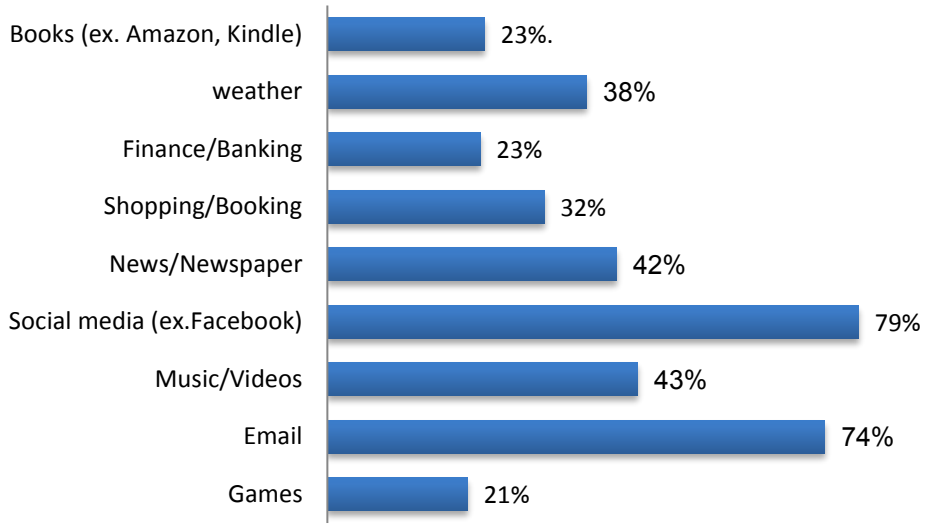

Figure 5.8: Most popular applications in smartphones

For web browsers, 68% of participants prefer Google Chrome browser, 18% prefer Safari browser, 7% Internet Explorer, 3% FireFox, 3% Opera and 1% Yandex. It is notable that Google Chrome is preferred on different platforms. To illustrate, 45% of users who own Apple smartphones prefers Google Chrome (see figure 5.9).

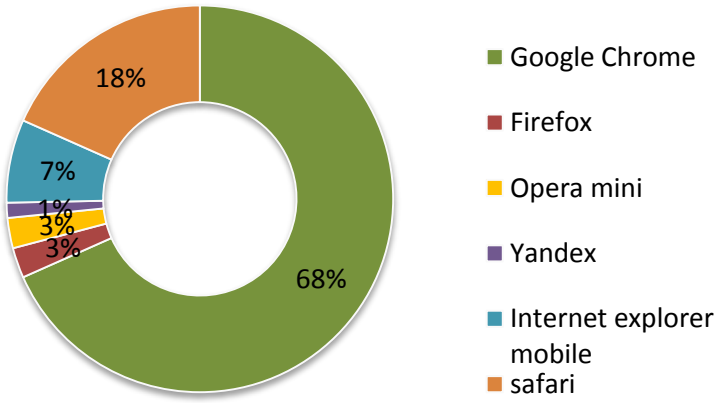

Figure 5.9: Most used Web browser

According to W3Counter report [63], 61% of users use Google Chrome, 16% use Safari, 8% use Internet explorer and 6% use Firefox. As in evident; the results are very close to ours.

Participants were asked to report the number of native applications they have on their smartphones and how many of those applications they really use in a typical day. From figures 5.10, 5.11; we can see that there is not a very big difference between the choices; 34% of participants have or download from 11-20 applications and 25% have more than 20 applications. But it is obvious that most participants use from 1-5 top applications in a typical day. In other words, regardless how many applications do users download they use only 5 applications per day. The same result is stated by Ahmet and Abdullah [23], they found that 58% of Bengali consumers use from 1 to 5 applications per day.

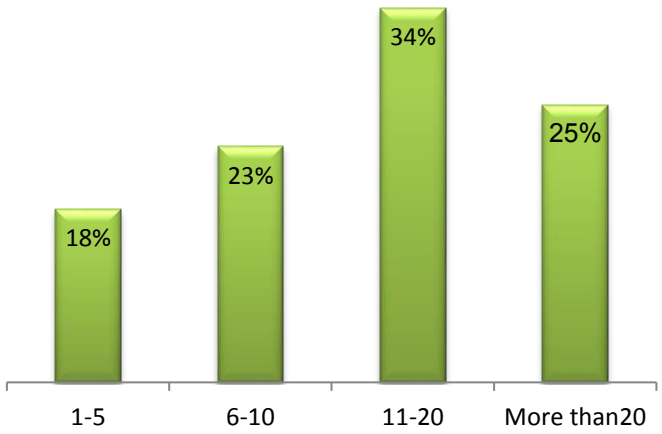

Figure 5.10: Number of downloaded and existing applications

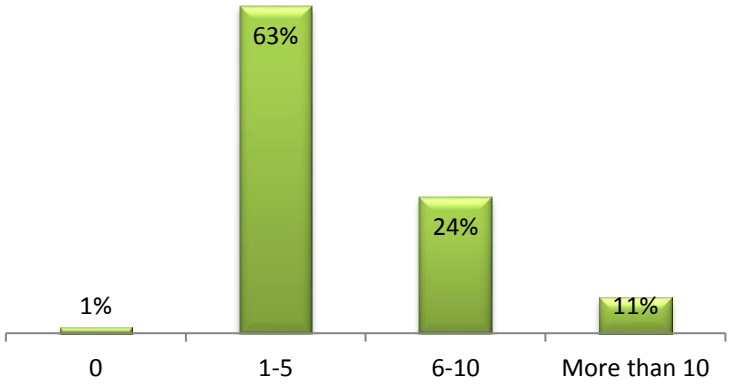

Figure 5.11: Number of used application in a typical day

Figure 5.12 shows a comparison between different studies in terms of average number of applications used per day.

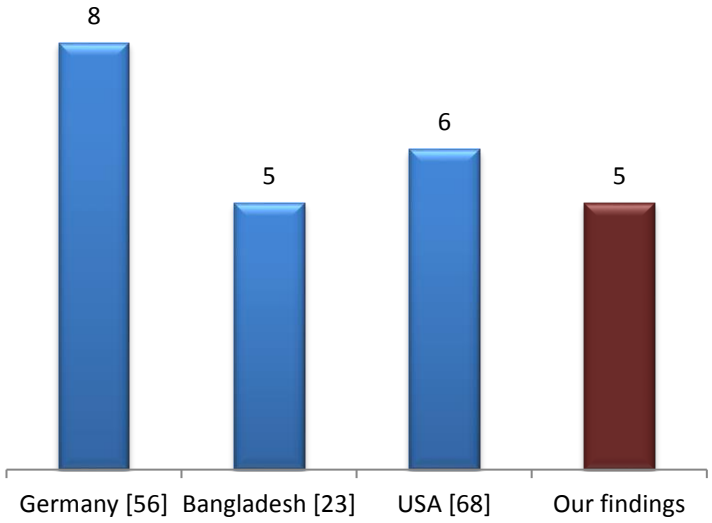

Figure 5.12: A comparison between different studies in terms of average number of apps used per day

For a list of 9 popular applications, participants indicated their preferences for "Mobile application" versus "Mobile website". Figure 5.13 illustrates how participants' preferences split between mobile applications and mobile websites. It is clear that mobile applications are extremely preferred for social media (like Facebook) and E-mail. We can see that the gap is the widest for social media (76% to 11%), Games (62% to 8%) and E-mail, while it is getting closer for shopping (38% to 42%). However, participants prefer mobile website when they read news or books. Along with this, we can say that participants prefer mobile applications to access the most frequently used applications while they prefer mobile websites for the less commonly used applications.

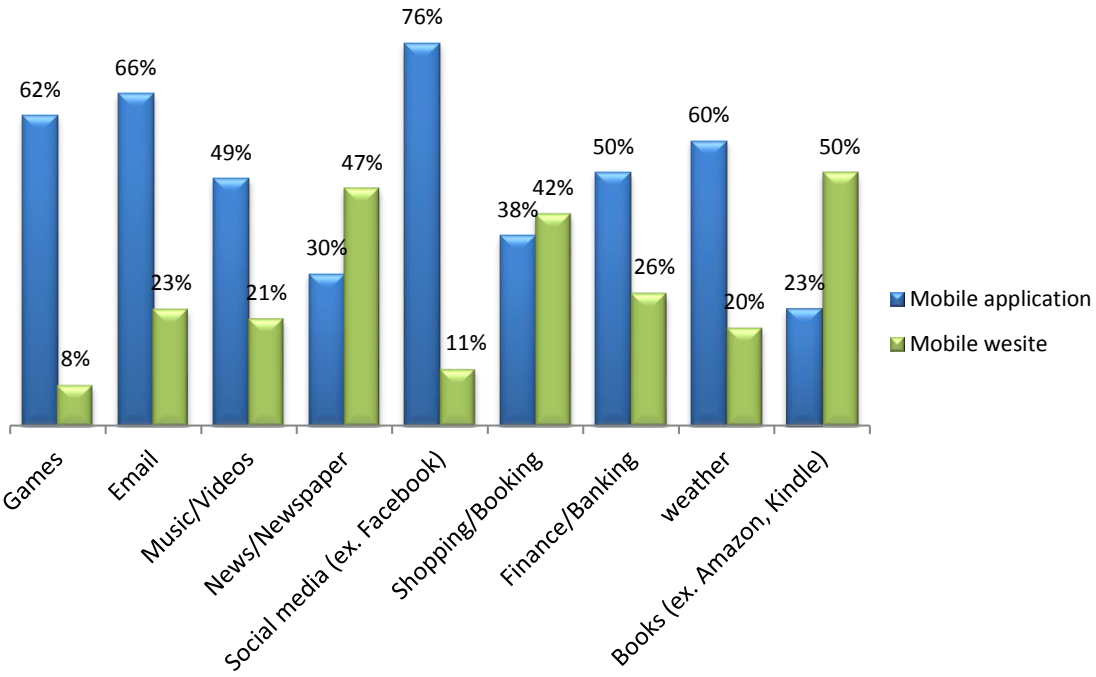

Figure 5.13: Student preferences for mobile access to popular applications

The survey also asked participants to compare between mobile applications and mobile website in terms of speed, eases of use, suitability, user experience and reliability. We can say that mobile application is better, according to participants as shown in figure 5.14.

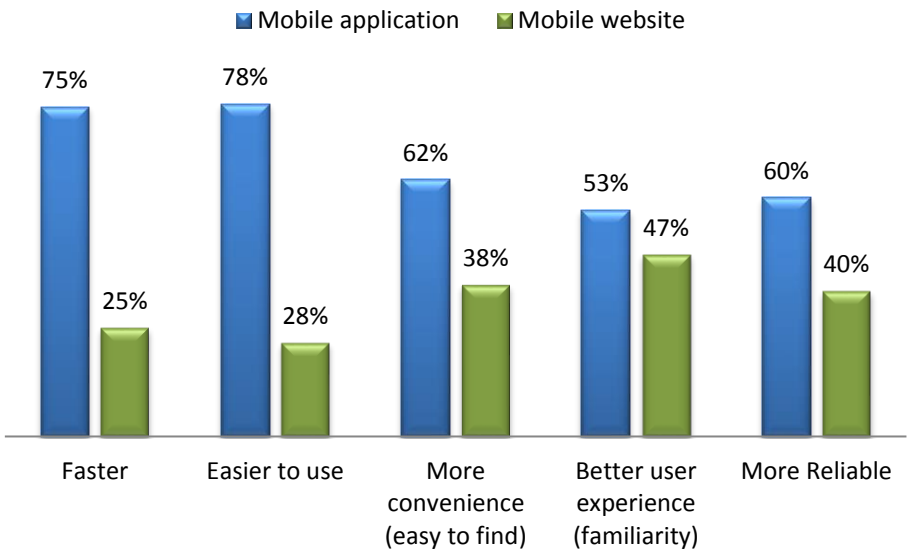

Figure 5.14: Mobile application vs. Mobile website

In a general question, 45% of participants prefer mobile applications and 16% prefer mobile websites, while 36% says it depends on the site. When participants were asked why they prefer mobile applications or mobile websites; 58% of participants who prefer mobile websites say that they don't want to install more applications on their smartphones while 26% say "because the application related to the website I want to visit doesn't exist or I cannot find it". 35% of participants who prefers mobile applications say that they prefer them because they have a better use, tailored to the mobile phone while 34% of participants say "It is easier to find, straight on my main screen, application list".

5.2.2. Correlations

The data collected from both online survey and paper survey was gathered and organized in an Excel spreadsheet then imported to PSPP. PSPP is a free alternative to the SPSS (propriety statistics program). It is very comparable to SPSS and has the data and variable view tabs, and has a layout that is almost identical to SPSS. Its option and output windows also look very similar to SPSS's. For feasible and meaningful analysis and to analyze the differences between responses from different subgroups, several statistical methods and tests have been used like ANOVA test and T-Test [61].

One Way ANOVA test was used in order to reveal whether the different operating systems appeal the graduation level groups in the same way or no. One Way ANOVA is used to indicate whether there are any significant differences between the mean of two or more independent groups or not. Levene statistic was (sig=0.358; >0.05) which illustrate that equal variances are assumed and parametric tests such as Independent T-test and One-way ANOVA test can be used. The result of One-way ANOVA test indicates that there is no difference between graduation level groups by the operating system; (sig=0.234, >0.05) that means the groups are not significantly different as shown in Table 1.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
graduation_level	1,08	3	154	,358

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
graduation_level	Between Groups	5,01	3	1,67	1,44	,234
	Within Groups	178,74	154	1,16		
	Total	183,75	157			

Table 5.1: One way ANOVA: graduation level groups in terms of operating system

We found that males and females have similar attractions to the operating system. In other words, they are not different. We used One way ANOVA test; the Levene test was set to (Sig=0.767,>0.05). The ANOVA result was set to (sig=0.787,>0.05) which means that males and females are not different in terms of choosing the operating system or mobile device type as illustrated in Table 5.2.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
gender	,38	3	154	,767

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
gender	Between Groups	,27	3	,09	,35	,787
	Within Groups	39,22	154	,25		
	Total	39,49	157			

Table 5.2: One way ANOVA**:** Gender groups in terms of operating system

In order to expose weather, the different graduation level groups spend time on their smartphones differently or not and if there is a relation between the graduation level groups and the time spent on smartphones. Firstly, One Way ANOVA test was used and Levene test indicated that equal variance could be assumed and the alpha level was set to (sig=0.76; >0.05) which means equal variance are assumed. The One Way ANOVA result has (sig=0.046; <0.05) that means the variance are significantly different as shown in Table 5.3.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
graduation_level	2,16	4	153	,076

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
graduation_level	Between Groups	11,22	4	2,81	2,49	,046
	Within Groups	172,53	153	1,13		
	Total	183,75	157			

Table 5.3: One way ANOVA: graduation level groups in terms of time spent on smartphones

Secondly, Bivariate Correlation test was used and the result shows that there is a negative relation between the graduation level and the time spent on smartphones. As shown in Table 5.4, (Sig=0.007; <0.05) that means the test is significant. The Pearson correlation value =-0.21. The (-) means the relation is negative which indicates that users who have higher graduation level spend less time on smartphones and the value 0.21 means the relation is not very strong.

Correlations

		graduation_level	time_spent
graduation_level	Pearson Correlation	1,00	-,21
	Sig. (2-tailed)		,007
	N	158	158
time_spent	Pearson Correlation	-,21	1,00
	Sig. (2-tailed)	,007	
	N	158	158

Table 5.4: Correlation: Graduation level with time spent

To assess the relation between the time spent by users and the number of applications used in a typical day, bivariate correlation was used and the result indicated that there is a positive correlation but it is a poor relation. The significant value (Sig=.001; <0.5) indicates that the test is significant and the Pearson correlation with value=0.26 indicates that the relation is positive which means the more users spend time on their smartphones the more applications they use but the relation is weak.

Correlations

		time_spent	app_use_day
time_spent	Pearson Correlation	1,00	,26
	Sig. (2-tailed)		,001
	N	158	158
app_use_day	Pearson Correlation	,26	1,00
	Sig. (2-tailed)	,001	
	N	158	158

Table 5.5: Correlation: Time spent on smartphones with number of applications used in a typical day

To expose if different age groups and graduation level groups have similar preferences between mobile applications and mobile websites or not; One Way ANOVA test was used. The Levene test result (sig=0.315; >0.05) for age groups and (sig=0.777; >0.05) for graduation level groups indicates that equal variances are assumed. ANOVA result (sig=0.269; >0.05) for age groups and (sig=0.186; >0.05) for graduation level groups indicates that both graduation level and age groups are not different in terms of their preferences.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
age	1,19	3	154	,315
graduation_level	,37	3	154	,777

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
age	Between Groups	3,22	3	1,07	1,32	,269
	Within Groups	124,71	154	,81		
	Total	127,93	157			
graduation_level	Between Groups	5,64	3	1,88	1,63	,186
	Within Groups	178,11	154	1,16		
	Total	183,75	157			

Table 5.6: ANOVA test for graduation level and age groups in terms of preferences

5.3. Data Analysis of Interviews

Based on the face to face interviews with participants who have tested the implemented applications (discussed in chapter 4) we have got the following analysis. When participants were asked about how they evaluate the two applications

in terms of speed, eases of use, suitability, familiarity and reliability; it seems that the gap between mobile application and mobile website is the widest in terms of easier to find while the area is close for other terms as shown in figure 5.15. Participants could not define their preference for speed, so we discarded it. Figure 5.16 shows a comparison between the survey results and the interviews results. It is clear that, the results are close except for easier to use where 78% of participants in survey say mobile applications are easier to use while in interviews 60% of participants say mobile applications are easier to use.

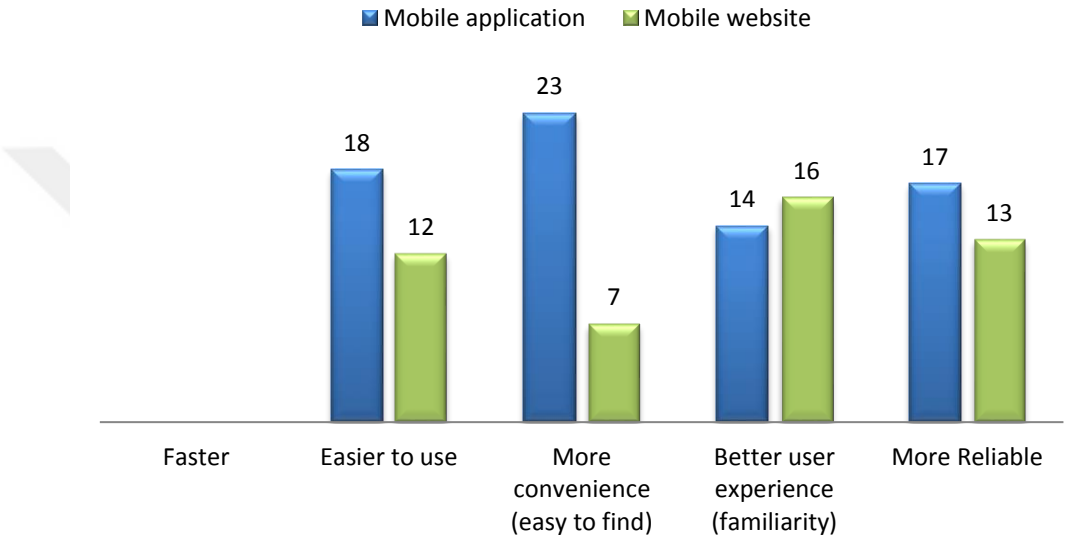

Figure 5.15: Interviews results

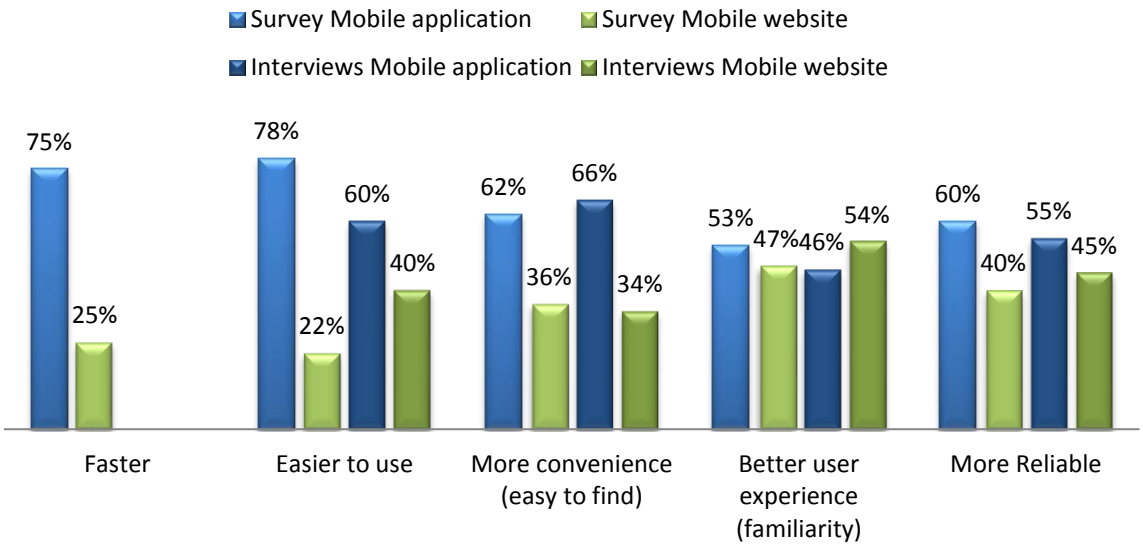

Figure 5.16: Survey vs. interviews results

CHAPTER 6

CONCLUSIONS and FUTURE WORK

The phenomenal growth and popularity of smart phones is a global phenomenon and the popularity of these devices is still expanding. The availability of Internet services around the world and the willingness to access them have been encouraged by almost every smartphone user to use the Internet on their phones either by mobile applications or via mobile websites. The aim of our research is to investigate the user preference between mobile applications and mobile websites. The first step in achieving this aim was conducting of a survey to understand the smartphone user behavior and preferences. Following the survey, interviews were conducted based on testing two implemented applications; a mobile application and a mobile website.

We can conclude our findings as follows:

- We found that 45% of respondents prefer using mobile applications on their smartphones while 37% say it depends on the site and the rest prefer mobile websites. This tells us that mobile applications are mostly preferred; however percentage of participants who make their preferences according to the site is close and cannot be neglected.
- Users who prefer mobile applications attribute this to ease of finding them on the smartphone's main screen and that they have a better use, tailored to the mobile phone. However, users who prefer mobile websites refer this to that they do not want to install more applications on their smartphones.
- Respondents are most likely to use between 1-5 applications per day regardless how many applications they have on their smartphones. This means that mobile application developers have a challenge to develop applications that makes users want to use it again and again.
- The top purposes of using the Internet on smartphones are social media, checking E-mail, watching videos and listening to music.

- For most important applications like social media; users prefer mobile application to access them while they prefer mobile websites for the least ones like reading news or books. Along with this, developers have to tap into the popular sphere to develop a considerably sticky application; otherwise they must develop a mobile website for more chance.
- Majority of respondents (63%) use Android, which means that for any company or individual developers, the Android market must be considered the key market.
- The average time spent on smartphones is 3 hours and we found that respondents with higher education level spend less time as well as that older respondents spend less time than the younger. So, focus should be more on the younger people by mobile developers.
- There is no significant relation between the graduation level of respondents and their preferences between mobile applications and mobile websites as well as for males and females.
- There is no significant relation between the graduation level of the respondents and their choices of smartphone operating system such as, Android and Apple.

Our study was limited in the educated sample. So, in the future research we suggest that the research on larger sample of not educated and younger people would generalize the findings to the whole population of Turkish consumers. Moreover, our interviews do not cover why people prefer mobile applications or mobile websites. In other words, we suggest in future work to consider any changes in the implementation of both native mobile application and mobile website in order to find out if these changes effects the user opinion. Future research could also consider other factors that might improve the findings such as performance issue, Internet connections availability, fees of applications and new desired application areas. Moreover, some valid programs or software can be used to track and measure the usage of certain applications and websites in order to measure the traffic of both applications.

REFERENCES

[1] Palo Alto, “Media alert: Smart phone shipments returned to growth in Q2 2016”, Canalys, July 2016. [Online]. Available: https://www.canalys.com/newsroom/media-alert-smart-phone-shipments-returned-growth-q2-2016. [Accessed: 12-Dec-2016].

[2] D. Sambasivan, N.John, S.Udayakumar, R.Gupta, “Generic Framework for Mobile Application Development”, 978-1-4577-1088-9/11/$26.00 ©2011 IEEE.

[3] A.Charland and B.Leroux,“Mobile application development: web vs. native”, Commun. ACM, 54(5):49{53, May 2011. ISSN 0001- 0782. doi:10.1145/1941487.1941504.

[4] S.Murugesan, “Understanding Web 2.0”, IEEE Computer Society. 1520-9202/07/$25.00 © 2007 IEEE.

[5] R.Voigts, S.Christmann and S.Hagenhoff, “Mobile Web Browsers”, Personal Ubiquitous Comput. 14(3):59–82, 2005.

[6] C.Yu and R.Miller, “Enhancing Mobile Browsing and Reading”, International Conference on Web Intelligence. doi:978-1-4503-0268-5/11/05.

[7] N.Fernandes, D.Costa, C.Duarte, L.Carriço, “Evaluating the Accessibility of Web Applications”, 4th International Conference on Software Development for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2012) doi: 10.1016/j.procs.2012.10.004.

[8] H.Habib and M.Ateeq, “A Study on Trends of Mobile Application usage and their Distribution Methods in Pakistan”, International Journal of Computer Science and Engineering (SSRG-IJCSE) – Volume 2 Issue 4–July to August 2012

[9] I.Dalmasso, S.Datta, C.Bonnet, N.Nikaein, “Survey, Comparison and Evaluation of Cross Platform Mobile Application Development Tools”, 978-1-4673-2480-9/13/$31.00 ©2013 IEEE.

[10] P.Smutný, “Mobile development tools and cross-platform solutions”, 978-1-4577-1868-7/12/$26.00 ©2012 IEEE.

[11] S.Geisler, M.Zelazny, S.Christmann and S.Hagenhoff, “Empirical Analysis of Usage and Acceptance of Software Distribution Methods on Mobile Devices”, 2011 10th International Conference on Mobile Business.

[12] R.Moloo, “Mobile Phone Usage Behaviour in Mauritius”, 2011 International Conference on Business Computing and Global Informatization. 978-0-7695-4464-9/11 $26.00 © 2011 IEEE.

[13] T.P. Fowdur, V.Hurbungs and Y.Beeharry, “Statistical Analysis of Energy Consumption of Mobile Phones for Web-Based Applications in Mauritius”, International Conference on Computer Communication and Informatics (ICCCI - 2016), Jan. 07 – 09, 2016, Coimbatore, INDIA.

[14] Y. Li, J.Yang and N.Ansari, “Cellular Smartphone Traffic and User Behavior Analysis”, IEEE ICC 2014 - Communication QoS, Reliability and Modeling Symposium.

[15] M.Tsai, “The Adoption Behaviors of Mobile Multimedia Internet Device (MMID) in Taiwan”, 2013 Proceedings of PICMET '13: Technology Management for Emerging Technologies.

[16] A.Jaffal and B.Le Grand, “Towards an Automatic Extraction of Smartphone Users’ Contextual Behaviors”, Research Challenges in Information Science (RCIS), 2016 IEEE Tenth International Conference: 978-1-4799-8710-8/16/$31.00© 2016 IEEE.

[17] H.Verkasalo, “Analysis of Smartphone User Behavior”, 2010 Ninth International Conference on Mobile Business / 2010 Ninth Global Mobility Roundtable.

[18] Q.Xu, J.Erman, A.Gerber and J.Pang , “Identifying Diverse Usage Behaviors of Smartphone Apps”, ACM 978-1-4503-1013.

[19] H.Hoehle and V.Venkatesh, “Mobile Application Usability: Conceptualization and Instrument Development”, MIS Quarterly Vol. 39 No. 2, pp. 435-472/June 2015.

[20] Yanqing Cui, Virpi Roto, “How People Use the Web on Mobile Devices”, Industrial Practice and Experience, ACM 978-1-60558-085-2/08/04.

[21] H. Falaki, D. Lymberopoulos, R. Mahajan, S. Kandula, and D. Estrin, “Diversity in Smartphone Usage”. ACM 978-1-60558-985-5/10/06 ...$10.00

[22] A. Mia, G.Jansen and M.Josias, “Smartphone Application Usage Amongst/ Students at a South African University”, IST-Africa 2012 Conference Proceedings Paul Cunningham and Miriam Cunningham (Eds) ISBN: 978-1-905824-34-2.

[23] S.Ahmed and Z.Abdullah, “A Study of Mobile Application Usage in Bangladesh”, SSRG International Journal of Computer Science and Engineering (SSRG-IJCSE) – Volume 2 Issue 4–July to August 2015.

[24] Q.Xu and J.Erman,“Identifying Diverse Usage Behaviors of Smartphone Apps”, IMC’11, November 2–4, 2011, Berlin, Germany. Copyright 2011 ACM 978-1-4503-1013-0/11/11.

[25] K.Bown, “Student preferences for mobile application usage”, Educause 2012 CC by-nc-nd.

[26] A.Gerontini and K.Moritz, “Large scale geospatial analysis on mobile application usage”, 2014 Eighth International Conference on Next Generation Mobile Applications, Services and Technologies.

[27] W.Jobe, “Native Apps vs. Mobile Web Apps”, Article in International Journal of Interactive Mobile Technologies (iJIM) October 2013.

[28] R.Madaudo and P.Scandurra, “Native versus Cross-platform frameworks for mobile application development”.

[29] A.Sommer and S.Krusche, “Evaluation of cross-platform frameworks for mobile applications”, 2016 International Conference on Interactive Mobile Communication, Technologies and Learning (IMCL).

[30] T.Mikkonen and A.Taivalsaari, “Apps vs. Open Web: The Battle of the Decade”, Annual Workshop on Software Engineering for Mobile Application Development, in connection with MOBICASE 2011, pp. 22-26. 2011.

[31] A.Charland and B.Leroux, “Mobile application development: web vs. native” ,Commun. ACM, 54(5):49{53, May 2011. ISSN 0001- 0782.doi: 10.1145/1941487.1941504.

[32] H. Karjaluoto, J. Karvonen, M. Kesti, T. Koivumäki, M. Manninen, J. Pakola, A. Ristola, and J. Salo, “Factors affecting consumer choice of mobile phones: Two studies from Finland”, Journal of Euromarketing, 14(3):59–82, 2005.

[33] M.Böhmer and A.Krüger, “A Case Study of Research through the App Store: Leveraging the System UI as a Playing Field for Improving the Design of Smartphone Launchers”, In International Journal of Mobile Human Computer Interaction (accepted: in press).

[34] M. Weiser, “The computer for the 21st century”, Scientific American, 265(3):66–75, 1991.

[35] History of GSM, “Technophone EXCELL PC105T – taking the mobile from the hand into the pocket (1986)”, [Online]. Available: www.gsmhistory.com/excell-pc105t. [Accessed: 5-Feb-2017].

[36] J.Scourias, “Overview of GSM: The Global System for Mobile Communications”, MS Thesis, University of Waterloo, 1996.

[37] Q. H. Mahmoud and P. Popowicz,“Toward a framework for the discovery and acquisition of mobile applications”, In 2010 Ninth International Conference on Mobile Business and 2010 Ninth Global Mobility Roundtable (ICMBGMR), pages 58–65. IEEE, 2010.

[38] J. Häkkilä and C. Chatfield. Personal customisation of mobile phones: a case study. In Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles, NordiCHI ’06, pages 409–412, New York, NY, USA, 2006. ACM.

[39] A. Holzer and J. Ondrus, “Mobile application market: A developer’s perspective”. Telematics and Informatics, 28(1):22–31, 2011.

[41] G. Bell and P. Dourish,“Yesterday’s tomorrows: notes on ubiquitous computing’sdominant vision”, Personal and Ubiquitous Computing, 11(2):133–143, 2007.

[42] A. Oulasvirta, T. Rattenbury, L. Ma, and E. Raita,“Habits make smartphone use more pervasive”, Personal Ubiquitous Comput., 16(1):105–114, 2012.

[43] S. Jenson,“Mobile apps and the approaching zombie apocalypse”, In Proceedings of the 12th international conference on Human computer interaction with mobile devices and services, MobileHCI ’10, pages 5–6, New York, NY, USA, 2010.

[44] Consumers and Mobile Financial Services 2016, Consumer and Community Development Research Section of the Federal Reserve Board’s Division of Consumer and Community Affairs (DCCA). Commun ACM, 54(5):49–53, 2011.

[45] A. Holzer and J. Ondrus,“Mobile application market: A developer’s erspective”, Telematics and Informatics, 28(1):22–31, 2011.

[46] R.Want, “You are your cell phone”, Pervasive Computing, IEEE, 7(2):2–4, 2008.

[47] T.Adinugroho, Reina and J.Bernadi, “Review of Multi-Platform Mobile Application Development Using WebView: Learning Management System on Mobile Platform”, International Conference on Computer Science and Computational Intelligence (ICCSCI 2015).

[48] U.Lee, J.Lee andM.Ko,“Hooked on Smartphones: An Exploratory Study on Smartphone Overuse among CollegeStudents”, Publication rights licensed to ACM 978-1-4503-2473-1/14/04.

[49] A. K. Dey, K. Wac, D. Ferreira, K. Tassini, J. H. Hong, and J. Ramos,"Getting closer: an empirical investigation of the proximity of user to their smart phones", In Proceedings of the 13th international conference on Ubiquitous computing, UbiComp '11, pages 163–172, New York, NY, USA, 2011.

[50] G. Anthes, "Invasion of the mobile apps", Commun, ACM, 54(9):16–18, 2011.

[51] Wolfson, Mike, and Felker. Android Developer Tools Essentials: Android Studio, O'Reilly Media, Inc, 2013.

[52] L.Ma, L.GU and J.Wang, "Research and Development of Mobile Application for Android Platform", International Journal of Multimedia and Ubiquitous Engineering, Vol.9, No.4, pp.187-198, 2014.

[54] M. Abou, El-Seoud and I. Taj-Eddin, "Beyond Android: an Essential Integration for better utilization", Interactive Mobile Communication, Technologies and Learning (IMCL), 2016 International Conference on, doi:10.1109/IMCTL.2016.7753780.

[55] Zapata, Cruz. Android studio application development. Packt Publishing Ltd, 2013.

[56] Gerpott, Torsten J., Sandra Thomas, and Michael Weichert. "Characteristics and mobile Internet use intensity of consumers with different types of advanced handsets: An exploratory empirical study of iPhone, Android and other web-enabled mobile users in Germany", Telecommunications Policy 37.4 (2013): 357-371.

[57] Lubbers, Peter, et al. Pro HTML5 programming. New York, NY, USA: Apress, 2011.

[58] Pilgrim, Mark. HTML5: Up and Running: Dive into the Future of Web Development, O'Reilly Media, Inc, 2010.

[59] R.Golhar, P. Vyawahare and A. Manusmare4, “Design And Implementation Of Android Base: Mobile App For An Institute”, International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) – 2016.

[60] Vrechopoulos, Adam, et al. “The critical role of consumer 52ehavior research in mobile commerce.” International Journal of Mobile Communications 1.3 (2003): 239-340.

[61] GNU PSPP, “PSPP”, [Online]. Available: https://www.gnu.org/software/pspp/. [Accessed: 22-Apr-2017].

[62] NetMarketShare, “Market Share Reports”. [Online], Available: https://www.netmarketshare.com/. [Accessed: 14-May-2017].

[63] W3Counter, “Browser & Platform Market Share”. [Online]. Available: https://www.w3counter.com/globalstats.php. [Accessed: 14-May-2017].

[64] Matthias Böhmer and Antonio Krüger,” A Case Study of Research through the App Store: Gaming the Android OS for Improving the Design of Smartphone Launchers”, International Journal of Mobile Human Computer Interaction (IJMHCI) 5.1 (2013): 45-61.

[65] Statista, “Number of available applications in the Google Play Store from December 2009 to June 2017”, [Online]. Available: https://www.statista.com/statistics/266210/number-of-available-applications-in-the-google-play-store/. [Accessed: 28-Feb-2017].

[66] Statista, “Number of available apps in the Apple App Store from July 2008 to January 2017”, [Online]. Available: https://www.statista.com/statistics/263795/number-of-available-apps-in-the-apple-app-store/. [Accessed: 28-Feb-2017].

[67] Statista, **“**Number of available apps in the Apple App Store and Google play from July 2008 to January 2017”, [Online]. Available: https://www.statista.com/statistics/263795/number-of-available-apps-in-the-apple-app-store/**.** [Accessed: 28-Feb-2017].

[68] Smart Insight, “Mobile Marketing Statistics compilation”, [Online]. Available: http://www.smartinsights.com/mobile-marketing/mobile-marketing- nalytics/mobile-marketing-statistics/. [Accessed: 11-May-2017].

APPENDIX A

A Survey: Mobile Applications vs Web Browsers

The aim of this survey is to find out what you prefer when you use the internet on your smartphones. The questions of this survey are about two alternatives. The first one is mobile application; it's the application that you download in your smart phone such as Facebook, Hürriyet gazetesi (Newspaper) and WhatsApp. The second alternative is mobile web browser where you search for your desired web site such as Google, Firefox and Opera.

1.

Under 18

18-24

25-30

Above 30

2.

What is your gender? Mark only one oval.

Male

Female

3.

Undergraduate student

Graduate student

Faculty

Staff

4.

Do you have a smart phone? Can you surf on the internet with your smart phone? Mark only one oval.

Yes

No

Don’t know

5.

Which operating system does your smartphone use? Mark only one oval.

Android

Apple

BlackBerry

Not sure

6.

How much time in a day do you use internet on mobile device or tablet? Mark only one oval.

I do not use internet on mobile

Less than 30 minutes

From 30 to 60 minutes

From 1 hour to 3 hours

From 3 hours to 5 hours

More than 5 hours

7.

How do you find your self as a smart phone user? Mark only one oval.

Expert

Advanced

Intermediate

Beginner

8.

What is your primary purpose for using internet on your mobile phone? Check all that apply.

Games

Email

Music/Videos

Social media (For example Facebook)

News/Newspaper

Shopping/Booking

Finance/Banking

weather

Books (For example, Amazon Kindle)

Other:

9.

Which browser do you prefer on your smart phone? Mark only one oval.

Google Chrome

Firefox

Opera mini

Yandex

Internet explorer mobile

Other:

10.

About how many apps do you currently have/did you install on your smart phone? Mark only one oval.

0

1-5

6-10

11-20

More than 20

11.

On a typical day, how many of those apps do you use? Mark only one oval.

0

1-5

6-10

More than 10

12.

Specify your access preference for the following type of applications Mark only one oval per row.

Mobile apps web browser

Games E-Mail Music/Videos News/Newspaper Social media (For example facebook) Shopping Finance/Banking weather Books (For example, Amazon Kindle)

13.

Select between mobile apps and web browser in terms of following characteristics Mark only one oval per row.

Mobile apps web browser

Faster Easier to use More convenience (easy to find) Better user experience (familiarity, habit) More Reliable

14.

In general what do you prefer to use when using Internet on your smartphone? Mark only one oval.

Web browsers

Mobile Application

Depends on the site

No preference

15.

If your answer was web browser, why do you use more web browsers rather than applications? Check all that apply.

More used to it (from experience with computers)

Because the application related to the website I want to visit doesnt exist or I cannot find it

I don’t want to install applications for random use

The applications from some websites are not functional, don’t work well

Usually I search for a general term, rather than needing a specific application.

Other, please specify .....

16.

If your answer was mobile application, why do you use more applications rather than web browsers? Check all that apply.

Better use, tailored to mobile phone

It is faster (Internet Speed)

It is easier to find, straight on my main screen, application list

Other, please specify .....

17.

If you have an enterprise what would you choose to improve your business? Mark only one oval.

Develop a mobile application

Develop a web site

Powered by

APPENDIX B

Interview Questions

1. Which application is faster?
2. Which application do you find easier to use?
3. Which application is more convince or easier to find on the mobile device?
4. Which application do you think is has better user experience or more familiar?
5. Which application do you think is more reliable?

APPENDIX C

Class Diagram with SQLite