PROGRESSIVE WEB APPLICATIONS AS A SOLUTION FOR BUSINESSES

Case study: Twitter

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Abstract

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Progressive web applications (PWA) are web applications with features such as accessing the camera, working while staying offline, navigation, like those of a native mobile application. This type of application makes use of the Web platform and aims to create an app-like experience while keeping the Web's low friction advantages. Inheriting the good of both worlds, PWAs can be a promising solution for businesses interested in expanding their customer reach to more than just users of the app stores.

This study attempts to explore the PWA, its current capabilities, and how it can be useful for businesses. The study also investigates end-users' attitudes towards this new type of application compared to the native mobile application in the social media context and focuses on end-users' preferences before and after knowing the differences between the two applications. The goal is to provide a starting point for businesses interested in serving their customers using PWAs.

The study follows the inductive approach, the qualitative strategy, and the case study research design. Twitter is chosen as the case. The study uses both primary data and secondary data. Secondary data is used to establish a general knowledge of PWAs and their current capabilities. The primary data is collected by conducting usability tests and interviews with end-users.

The study shows that most users choose the PWA for its design. Most users also feel that the native mobile application is smoother than the PWA. Importantly the main reason for switching from a PWA to a native mobile application is the lack of features, such as push notifications, filters, and editing tools for taking photos. These findings emphasize the importance of user interface design when a user chooses between these two applications. Based on the findings, several suggestions are given for businesses that are interested in the PWA.

Keywords

progressive web application, user research, Twitter, native mobile application, business solution

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1 INTRODUCTION

1.1 Problem identification and background

The World Wide Web (the Web) has been a great source of information and entertainment. People can visit various websites for whatever purposes, from chatting with friends, ordering food, booking a flight, and learning a new skill to filling migration forms. In recent years, the Web has expanded its capabilities to handle more than just searching keywords and displaying information and has changed to support increasing mobile users. The Web can now tab into functionalities such as accessing the camera, receiving the push notification, displaying offline content, accessing through home screen icon, navigation, which were earlier thought to be exclusive for mobile applications. (Biørn-Hansen, Majchrzak, & Grønli 2017, 344.) One prominent example of these innovations of the Web is the Progressive Web Application (PWA). This new type of web application aims for creating a mobile-app-like experience while keeping the Web's low friction advantage (Osmani 2020). It is safe to say that the PWA is making the line between websites and mobile applications blurrier (Biørn-Hansen et al. 2017, 349). Therefore, by looking into this new option, companies may discover a new solution for serving customers either with or without current mobile platforms.

On the other end of the spectrum, several lawsuits and investigations have been opened against the primary downloading platforms for mobile applications - Apple's App Store and Google's Play Store. The lawsuits focus on how each stores' rules and in-app payment have led to unfair competition among Apple, Google, and other mobile application providers. Noticeably, in June 2020, the European Commission opened several investigations on Apple about its App Store's rules and its in-app payments in response to complaints from Spotify and an e-book/audiobook distributor in 2019. (European Commission 2020a; European Commission 2020b.) In August 2020, Epic – the maker of the cross-platform game Fortnite, after being kicked off Google's Play Store and Apple's App Store for allowing users to pay for purchases using a competing payment processor instead of using official systems, sued both the two leading companies (The Fortnite Team 2020; Epic Games 2020a; Epic Games 2020b). These situations have highlighted more and more the direct dependency of companies on Apple's or Google's platform and the indirect dependency of consumers on these companies.

The advancement of the Web and the problems of popular platforms create new realities and open new opportunities for companies. The PWA offers a solution for serving customers without being dependent on the app stores, and still creating an app-like experience

(Biørn-Hansen et al. 2017, 345). To make full use of this new type of application, companies must understand what PWAs are capable of, and how customers see and use these applications. This thesis studies the current capabilities of PWAs and investigates the behaviors of customers when using them.

1.2 Motivations

At the beginning of 2017, there was a lack of academic research on the PWA (Biørn-Hansen et al. 2017, 345). However, more and more research, studies, student theses have been done about PWAs since then. One of the research studied the impact of service workers on the energy efficiency of PWAs. The research showed that the use of service workers had negative but minimal impacts on the energy consumption of these applications. As a result, the researchers concluded that the PWA and the service worker technology were promising in terms of energy efficiency. (Malavolta, Procaccianti, Noorland & Vukmirovic 2017, 35-45.) In the user experience aspect, a student thesis by Sedkowska compared user attitudes towards different user interfaces between a progressive web application and a mobile native application in the social media context. The study concluded that, despite noticing the user interfaces, most participants thought that the PWA was a native mobile application. The study results showed that most participants preferred using the PWA in the future. (Sedkowska 2020, 17.)

Different from the two research above, this study focuses on the preferences of end-users before and after knowing the differences between the two types of applications. Furthermore, the study aims to create an overview of the PWA, exploring its core technologies, capabilities, and support suitable for business use and not dive deep into the technical details of the PWA.

It is important to understand the behaviors of end-users when interacting with a PWA, together with its current capabilities, support for companies to maximize the PWA's potentials, and to have a good strategy using it. On the other hand, the PWA inherits some good features of both mobile applications and the Web which has the potentials to bring about new mobile experiences for both businesses and end-users. These reasons make the PWA an interesting topic for study.

1.3 Research purpose and questions

This research attempts to explore the progressive web application, its current capabilities, and how it can be useful for businesses. The research also investigates end-users' behaviors towards this new type of application compared to the native mobile application. The

research goal is to create a starting point for businesses interested in serving their customers using progressive web applications.

Next, it is important to identify the research questions. Wilson (2014, 54) describes the research questions as “the glue that holds the project together”. The research questions help setting boundaries for literature review, propose suitable research methods, and produce more refined results (Wilson 2014, 71). Therefore, it is important to have good research questions. The main research question is defined as follow:

- **Why businesses should choose progressive web applications as a solution?**

To answer this, several sub-questions are needed as followed:

- **What is a progressive web application?**
- **What capabilities and limitations do progressive web applications have?**
- **How do end-users view progressive web applications?**

The first and second questions aim at creating a general view of a PWA, its capabilities, and metrics valuable for business use. The third question seeks to understand how end-users see PWAs and in what ways PWAs are solving problems these users have with mobile applications. Based on these, businesses can create new solutions for serving customers, whether to replace mobile applications with PWAs or to implement both. The research results may also shed light on how the PWA can improve to suit both business requirements and user needs. Even without the need for investing in PWAs, the research hopes to be beneficial for companies developing mobile applications as it points out the disadvantages that can be a deal-breaker when customers choose and use the applications.

1.4 Thesis structure

Figure 1 illustrates the structure of this thesis. The thesis is divided into five chapters. The first chapter introduces the topic and identifies research purposes and questions. The second chapter gives an overview of the progressive web application, its current capabilities, and support in a format suitable for business use. The third chapter lays out the research design and different methods used for exploring different attitudes of end-users towards the PWA. The fourth chapter presents the data collected and analyze these data. At the end of the chapter, several suggestions for businesses that are interested in serving customers using the PWA are given. Lastly, the fifth chapter concludes this thesis by presenting the key findings, addressing the research limitations, and suggesting ideas for future research.

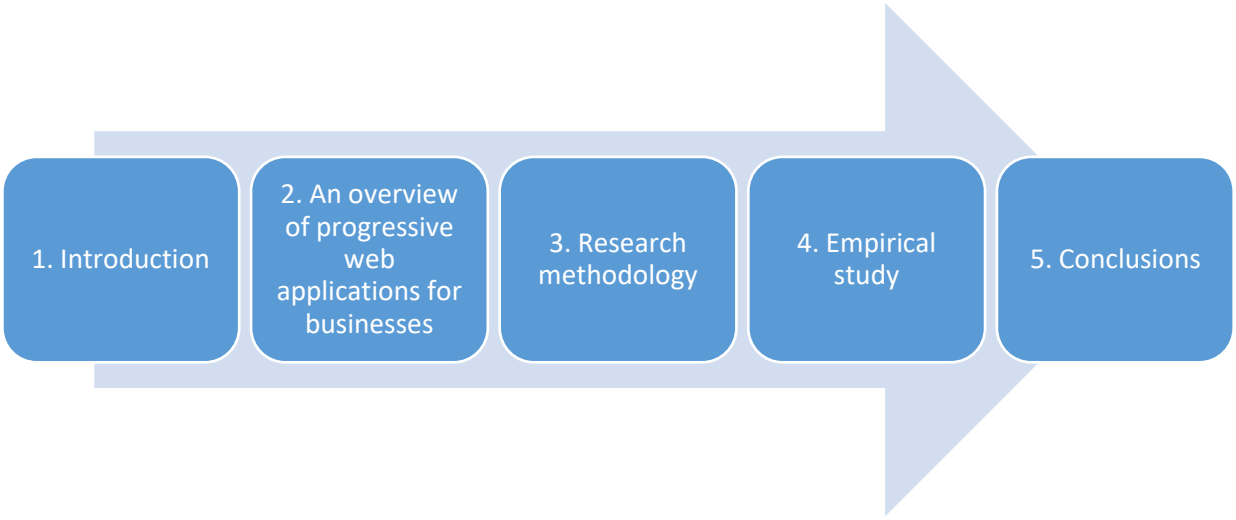

Figure 1 Thesis structure

2 AN OVERVIEW OF PROGRESSIVE WEB APPLICATIONS FOR BUSINESSES

2.1 History of progressive web applications

This chapter provides some background on the concept of the progressive web application. Section 2.1 first introduces the history of progressive web applications. Section 2.2 then proceeds to discuss different technologies that make up a progressive web application, as well as the current capabilities and support for these applications.

Since 2014, developers have been trying different approaches to develop mobile applications using web technologies. Two of them are the Packaging approach – bundling Hypertext markup language (HTML), Cascading style sheets (CSS), and JavaScript as data and display these data in the native application through a full-screen browser widget and the Cross-compilation approach – translating one language (for instance JavaScript) to another language (such as Objective-C for iOS applications) to compile the native application from the web application. (Puder, Tillmann & Moskal 2014, 18-26.) According to Russel (2015), these approaches and many more help developers tab into features common to mobile applications such as push notification, using geo-location, accessing sensors data while allowing them to develop using web technologies. However, they also sacrifice some shared values of the Web on the way. Russel stated:

> *They frequently give up linkability in return for "appiness": to work offline, be on the home screen, access system APIs, and re-engage users they have required apps be packaged, distributed through stores, and downloaded entirely before being experienced. (Russel 2015.)*

The Google Web Fundamentals group and Russel advocated one approach which instead introduced such features directly to the Web. Russel and his wife Frances coined this approach Progressive web application (PWA). MDN contributors (2020b) agree that the PWA is a philosophy for developing web applications, is built using a compilation of application programming interfaces (APIs) rather than one single technology. The PWA aims to deliver an app-like user experience using modern web capabilities (Osmani 2020). Moreover, Osmani (2020) suggests that a PWA works on old browsers and is progressively enhanced on modern ones. “The Progressive enhancement is a backbone of the model” (Osmani 2020).

In his blog Infrequently Noted, Russel (2015), together with Frances, summed up core attributes for this new class of applications:

- Responsive (fit any form factor)
- Connectivity independence (can work offline)
- App-like-interactions
- Fresh (always has up-to-date content)
- Safe (served via Transport Layer Security protocol)
- Discoverable (can be searched on the Web)
- Re-engageable (e.g., push notification)
- Installable (be on the home screen with an app icon)
- Linkable (easy to share via links)

The application blends some of the best features of the Web platform as well as that of native mobile applications. Users can enjoy an app-like experience and at the same time share the applications with others, explore new applications without waiting for long installations, just like using websites.

2.2 Progressive web applications' core technologies and their support

One of the worries of companies when choosing a technology for their products is the technical support. Technological support is important as it affects the development process – available documents and resources, available features, available frameworks, and libraries, debugging ease, etc. The support also affects the maintainability, scalability of the application in the future. The same logic can be applied to the PWA.

Unlike mobile applications, there is no dependence on stores as the PWA lives on the Web. However, it also means PWAs are tightly tied to the user's browser. One's browser support for the PWA, such as whether the browser support features out of the box or it needs special adjustment to run the PWA smoothly, is important in this case.

As noted in the previous section, the PWA is not built using one single technology. PWAs use specific patterns and different APIs (MDN contributors 2020b). Therefore, in the next sections, the thesis goes through the core technologies of a PWA, its capabilities, and the supports for these technologies on some popular mobile browsers, namely Chrome for

Android, Safari for iOS, Firefox for Android, Opera for Android, and Samsung Internet. Next, testing features of the PWA are introduced.

In the scope of this thesis, not all technologies and features of the PWA are going to be covered. This study aims to create a general view of the PWA's current capabilities and supports and not diving deeply into reviewing the PWA's technical details. Based on this knowledge, the study then investigates how end-users use it.

2.2.1 Core technologies

Web app manifest

A web app manifest is a JSON text file that contains information about the web application such as the web app's name, application icons with different resolutions, preferred uniform resource locator (URL) as a starting point when the user launches the application, just to name a few. The manifest allows PWAs to be downloaded and be on the user's home screen. Furthermore, developers can customize the application to be displayed as full-screen like a native mobile application, to be portrait or landscape-oriented, and much more for a mobile-application-comparable experience. (W3C 2020.)

Table 1 shows the current support for web app manifest on different mobile browsers. The level of support can be assumed from measuring the compatibility for a few properties of the manifest on different browsers. The data was sourced from the Mozilla website (https://developer.mozilla.org/en-US/docs/Web/Manifest) – accessed on 6 November 2020. As suggested from the table, Chrome, together with Samsung Internet, has the most support for the web app manifest. Followed are Firefox and Opera. Safari, on the other hand, does not have supports for the listed properties of the manifest. Osmani (2020) also declares that there have not been public signals from WebKit/Safari to implement this feature.

Table 1 Web app manifest's supports on browsers (MDN contributors 2020d)

	Properties Description	**Chrome for Android**	**Firefox for Android**	**Opera for Android**	**Safari on iOS**	**Samsung Internet**
background_color	Background colors for the site when the app's stylesheet is not ready	Yes	?	Yes	?	Yes
display	Determining the preferred mode for viewing the app	Yes	Yes	?	?	Yes
icons	Icons for displaying the app on the home screen	Yes	Yes	?	?	Yes
name	Name of the app to display to users	Yes	Yes	?	?	Yes
short_name	A short name to display for users when there is not enough space	Yes	Yes	?	?	Yes
theme_color	Sometimes affect how the site is displayed (e.g., The value of theme_color is used to surround the site on Android's task switcher)	Yes	Yes	?	?	Yes

Service worker

The service worker is a file written in JavaScript that the browser runs in the background, separate from the web page (Gaunt 2020). For this reason, Gaunt (2020) suggests service workers make it possible to run different features without the need for a web page or user interactions – sending user push notifications is one of them. Service workers also leverage the offline-working capabilities for PWAs (MDN contributors 2020c). MDN contributors (2020c) state that the service worker is like a proxy server, a middleman among the application, the browser, and the network. By interfering with requests, the service worker can act according to the network situation, for example choosing to load resources from the cache when there is no network available and update resources when there is network again. This helps create an effective offline experience (MDN contributors 2020c).

According to the service worker's implementation tracker by Jake Archibald, the service worker has been shipped with popular browsers, including Chrome, Firefox, Opera, Samsung Internet, Safari, and Edge. Most building blocks of the service worker are also supported, for instance, the Promise object, Cache Storage, Fetch API, and so on. However, it is worthwhile to note that service worker support for iOS does not include third-party browsers and only includes Safari. (Archibald 2018.)

Push API

As the name suggests, the Push API helps push new messages and updates to users. The Push API makes use of service workers as service workers run in the background, separate from the web page (Medley 2019). Because of this, users can receive push notifications regardless of the web application running in the foreground or not (MDN contributors 2020a). By making use of the Push API, companies can effectively re-engage the users to the application. Users, on the other hand, can enjoy updates from their favorite applications. (Medley 2019.)

Osmani (2020) suggests that Chrome has implemented the Push API and Firefox is in the development process. Opera and Samsung Internet also support the Push API (MDN contributors 2020a). Safari on iOS, however, does not support the Push API for now (Osmani 2020).

2.2.2 Testing features

In the last section, the study covers some of the widely supported features of PWAs, including the add-to-home-screen feature, caching data for working offline or for future faster load and, sending push notifications. There are also testing features that are yet to

be finalized and are not widely supported. Excluding the poor support, the features show the potentials of PWAs to be on par with native mobile applications.

Web Bluetooth

Bluetooth is a standard that helps communication between devices within a short range (W3C Community Group 2020). Before 2015, Bluetooth was exclusive for native applications (Beaufort 2019). In his article “Interact with Bluetooth devices on the Web”, Beaufort stated that the Web Bluetooth API aims to break this limitation and to bring Bluetooth to the web browsers (Beaufort 2019). Specifically, Bluetooth 4.0 introduces a new transport mode called “Bluetooth Smart” (BLE) for discovering, communicating between devices with low energy consumption using the Generic Attribute Profile (GATT). GATT protocols support not only “BLE” transport but also Bluetooth classic mode transport “BR/EDR”. Web Bluetooth API makes use of GATT protocols to enable these features on the Web. (W3C Community Group 2020.)

Web Bluetooth API is not widely supported now. As reported by Mozilla, support for Web Bluetooth API is currently available on Chrome for Android, Opera for Android, and Samsung Internet (MDN contributors 2019). Firefox status for the feature is “Considering” and WebKit/Safari status is “Not planned” (Mozilla 2020).

Face ID and Touch ID for the Web

In the Apple worldwide developers conference 2020 (WWDC 2020), Apple (2020) announces that it is enabling Face ID and Touch ID for the Web by making use of the Web Authentication API (WebAuthn API). This means a web application can make use of Apple’s biometric authentication to register and authenticate a user.

To understand how Apple enabled this type of authentication for the Web, a brief introduction to the Web Authentication API is provided. This API uses asymmetric cryptography (public key – private key pair) to replace the need of using passwords, SMS texts for registering and authenticating with websites (MDN contributors 2020e). There are several essential components of this API: the server (also referred to as a service or a relying party), the authenticator, and the attestation. The API manages credentials that can be used to register or authenticate a user on a server (e.g., a website). These credentials are created and stored in a device called the authenticator in form of key pairs. Examples of authenticators are Windows Hello – an authenticator embedded into the operating system; USB – an authenticator as a physical token. (MDN contributors 2020e.) In case a highly secured website (e.g., a bank website) needs more information from the device, the attestation feature is used to send extra information to the website (Apple 2020).

Apple built a platform authenticator – an authenticator built into the platform – by making use of the Web Authentication API and the Face ID and Touch ID on its device. The company also built its attestation server, called Apple Anonymous Attestation to further enhance security. (Apple 2020.) According to Tan (2020), the Face ID and Touch ID for the web feature is available in Safari on iOS 14, iPadOS 14, and macOS Big Sur.

Lastly, Safari is not the only browser that supports the Web Authentication API. According to MDN contributors (2020e), Chrome for Android and Firefox for Android also support most features of this API. On the other hand, Opera for Android and Samsung Internet support some features of the API.

3 RESEARCH METHODOLOGY

3.1 Research approach

As suggested in the introduction, understanding end-user attitudes toward PWAs is crucial for companies to make use of PWAs and maximize their potentials. Based on this knowledge, this research is created to observe different attitudes end-users have with PWAs, what they like, and what they find irritating when using a PWA as compared to using its native mobile application counterpart. This chapter lays out the research approach, research strategy, research design, different methods used, and the reasons for these selections.

There are two main research approaches: the inductive approach and the deductive approach (Wilson 2014, 32). The inductive or empirical approach, stated by Hyde (2000, 82), is “a theory building process”. Inductive research starts with observing specific instances and try to establish patterns or generalizations of these observations in the end. Another approach is the deductive or rational approach. Hyde (2000, 82) defines this as “a theory testing process”, where practitioners try to see if one theory applies to the investigated instances. As the research attempts to investigate different attitudes of end-users using PWAs, the inductive approach is the more suitable choice.

3.2 Research strategy

After choosing the approach, the research strategy is also decided. Wilson (2014, 37-39) suggests two main research strategies: qualitative and quantitative. “In short, the main difference is that quantitative research is usually associated with numerical analysis, while qualitative is not” (Wilson 2014, 38). Hyde (2000, 84) adds that quantitative methodologies seek to describe the general characteristics of a population, while qualitative methodologies aim for explaining the particular. He stated, “Qualitative methods allow the researcher to study issues in depth; data collection is not limited to predetermined categories” (Hyde 2000, 84). In the case of this research, it is important to gather end-users’ opinions on different aspects of PWAs, as well as other aspects that might affect their opinions on PWAs. The qualitative strategy is, therefore, more suitable.

3.3 Research design: a case study design

Wilson (2014, 133) defines the term “research design” as a detailed plan or framework on how the research processes. According to Wilson (2014, 132), having a research design increases the chance of achieving research objectives. Therefore, it is important to

choose a research design before implementing the research. Some different research designs are action research, case study, experimental, longitude, cross-sectional, etc. This research makes use of the case study design. “A case study is an empirical method that investigates a contemporary phenomenon (the “case”) in depth and within its real-life context, especially when the boundaries between phenomenon and context may not be clearly evident” (Yin 2018, 45). Yin (2018, 32) suggests using case study design when [1] the main research questions are “how” and “why” questions, [2] there is little or no control over behavioral events, and [3] the study focuses on a contemporary phenomenon. In the case of this research, a case study design is a viable solution.

One of the ways of dividing the case study is by scope (Wilson 2014, 138). Case study research can analyze one or many cases. A single case study is suitable for conducting an in-depth study or used for piloting before extending the research to examine multiple cases. Multiple cases study, on the other hand, can produce more robust research results (Wilson 2014, 138). Because of the time and the resource constraints, this research uses the single case study. Particularly, Twitter is chosen as the case study. The platform is chosen because there are both the Twitter PWA application and the Twitter native mobile application for comparison.

3.4 Data collection methods

In general, there are two types of data: primary data and secondary data**.** The data collected by the researcher for his study is primary data. On the other hand, secondary data is data that has already been published. (Wilson 2014, 164.) Examples of secondary data can be previous studies or research about the same topic being studied. This study makes use of both primary data and secondary data. In the second chapter of this thesis, secondary data is used to establish a general knowledge of the PWA and its current capabilities. On the other hand, primary data is collected by conducting a usability test with end-users, combined with interviews before and after the test.

However, usability testing may not seem like a good choice. Goodman, Kuniavsky & Moed (2012, 273) state that this technique examines how people perform specific tasks and therefore not good to study the entire experience with a product or service. To resolve this problem, different tasks that cover the main features of the application are selected. Furthermore, by having the respondents doing tasks on both the PWA and the native mobile application, the test hopes to create a general view of the PWA in comparison with the other application. Based on this general view created by the usability test, the interview then dives into how end-users feel about two applications when doing the tasks, their preferences, and suggestions for these two applications in general.

3.4.1 Usability test design

"Usability tests are structured interview focused on specific features in an interface prototype" (Goodman et al. 2012, 273). The usability test focuses on the series of tasks performed by the respondents, who resemble the actual product's audience. After analyzing notes and recordings of respondents' opinions, the researcher and the development team can immediately discover how people understand and use the designs. (Goodman et al. 2012, 273.) Table 2 shows the tasks and scenarios to help the respondent understand what to do on the Twitter PWA and the Twitter mobile application.

Table 2 Tasks and scenarios for the usability test

	Task	**Scenario**
1	Create a Tweet and add an image to it.	Imagine you come to a party and want to tell your followers about this event, together with a picture of you there. Please create a Tweet and add an image for this purpose.
2	Follow or block one person.	Imagine you heard about a public figure from your friend. You like/dislike this person, and therefore want to follow/block the person to allow/prevent notifications about him. Please try to do this on the application.
3	Go to the app settings and change the background to a darker color.	Imagine you are using the application at night, and the application's default background is too bright and causes irritation for your eyes. You want to change this background to a darker color. Please try to find this feature and change it in the app settings.

It is decided that the respondent can choose which application to use first. Before the test, a quick demonstration of how to navigate the application is provided. However, the respondent is not given any information regarding how these two applications differ at this time. During the test, all participants would use the same iOS device connected to the network, provided by the researcher. One Twitter account is created for respondents to use.

3.4.2 Interview design

Together with the usability test, an interview is designed to discover different opinions of respondents on the two applications. Wilson (2014, 176) suggests three types of interview methods: structured, unstructured, and semi-structured. A structured interview can generate short and concise answers of the respondents from a strict set of questions but may not allow respondents to elaborate on the answers. Therefore, a structured interview might lose potentially interesting data. An unstructured interview or in-depth interview, on the other hand, begins with a broad question. Respondents can discuss in a general and open manner. The disadvantages of this approach, however, are the inconsistency in the answers and the risk of being off-topic. (Wilson 2014, 176.) This research makes use of the third, hybrid approach – semi-structured interview. According to Wilson (2014, 177), a semi-structured interview has a set of structured questions to be answered by the respondents, as well as a flexible scope for them and the researcher to raise other questions and ideas.

This research splits the interview into two parts. The first part is about how the respondents use social media in general. The second part is about their experiences with the PWA application and the native mobile application. The first part is asked before the usability test, while the second part is asked during and after the test. Table 3 shows the questions for these two parts.

Table 3 Interview questions

	Part 1		**Part 2**
1	How often do you use social media (answer in hours per day)?	**6**	Did you notice any differences in the user interface when doing the tasks? If yes, what are they?
2	Name some of the social media you usually use.	**7**	What do you think about these differences? What do you like and dislike about these two applications?
3	Do you use the website or the application to access these platforms?	**8**	Which application makes it more difficult to do the tasks?
4	Have you used the website to access these platforms on your mobile before?	**9**	Which application will you choose if you are to use Twitter in the future?
5	Have you heard of Twitter before?	**10**	After knowing the information, do you have a second thought?

After finishing the interview, the respondents are informed about the two applications, their advantages, and limitations which might not be discovered during the usability test. The respondents are then asked again which application they prefer. The answers and potentially interesting ideas would be noted. The respondents are also asked in advance if the interview can be recorded only for research purposes.

3.5 Sampling methods

For this research, the sample size is six people. The respondents are bachelor's degree students from LAB University of Applied Sciences. The reasons for this choice are to expect respondents to familiar with social media; to expect respondents to use mobile phones and mobile applications. Due to different limitations created by the COVID19 pandemic, the convenience sampling technique is chosen. This technique selects participants who are readily and easily available (Wilson 2014, 229).

3.6 Data analysis methods

This research applies the four steps in qualitative analysis, introduced by Wilson (2014, 285-286):

- transcribing data
- reading and generating categories, themes, and patterns
- interpreting findings
- writing the report.

Firstly, the interviews are transcribed. Interesting observations during the usability are noted. Secondly, the data is coded. Coding data means selecting different elements of the data which might be interesting and relevant to the study. Examples of a code can be a keyword, a theme, a category within the data. (Wilson 2014, 288.) This research makes use of the emergent coding approach, in which the codes would be developed during examining the data. Thirdly, categories are built up, patterns are drawn from the coded data. Lastly, the findings would be interpreted and discussed.

4 EMPIRICAL STUDY

4.1 A brief comparison between the two applications

This chapter implements the research and reports the results. Section 4.1 first provides a brief comparison between the two applications. Section 4.2 presents the data collected, including the basic information of each participant and interesting observations from his or her usability test. The summaries of six interviews can be found in appendix 1. Section 4.3 then analyzes the data and discusses the findings. Finally, section 4.4 goes through several suggestions for businesses interested in the PWA based on the findings of this research.

Before implementing the usability tests and interviews, a brief comparison between the Twitter PWA and the Twitter native mobile application was made. Several differences were noted. The differences were categorized into two sections: User interface and features; Storage and installation.

User interface and features

Overall, the two applications share the same user interface. However, there are major as well as less visible differences between the two applications. More options are visible in the sidebar of the PWA while some are hidden in that of the native mobile application (Figure 2). In the Tweet creation form, the PWA does not show suggestions for adding an image to the Tweet while the other application does (Figure 3). The application background setting of the PWA has more customization than that of the native mobile application (Figure 4). Furthermore, interactions with the PWA are not as smooth as those with the other application. There are also fewer animation effects on the PWA.

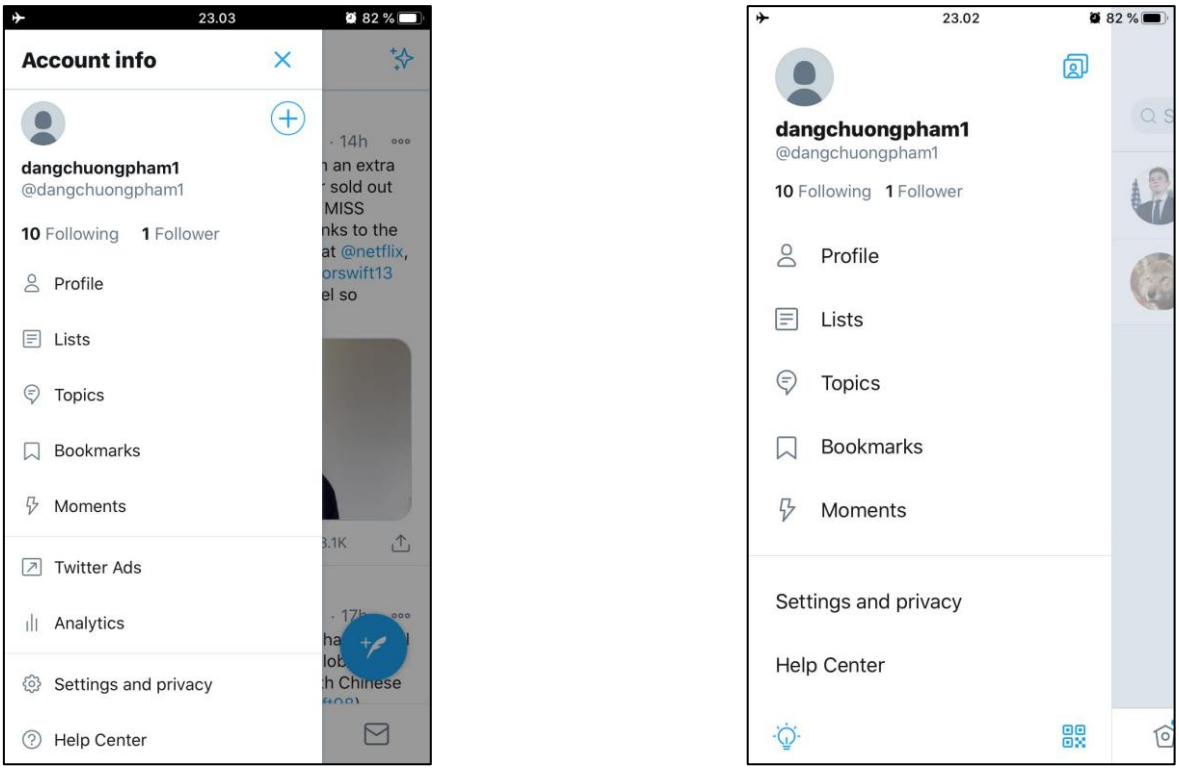

Figure 2 The sidebar on the PWA (left) and on the native mobile application (right)

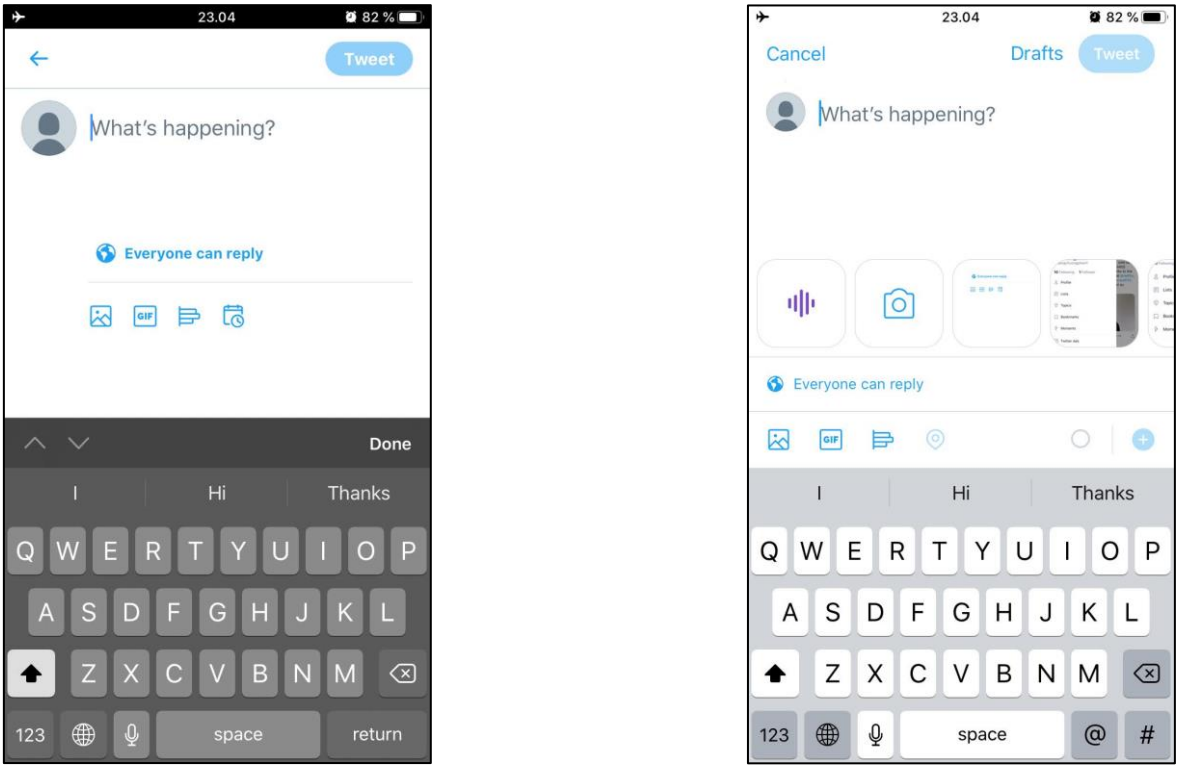

Figure 3 The Tweet creation form on the PWA (left) and on the native mobile application (right)

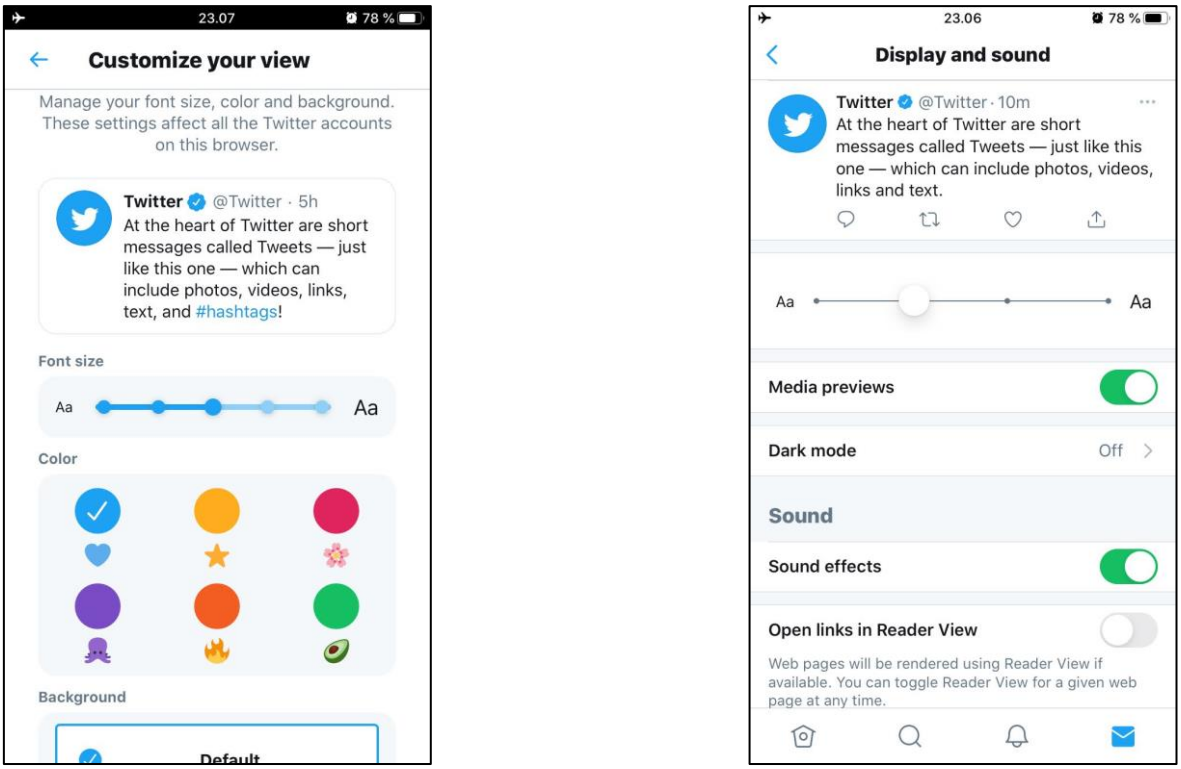

Figure 4 The background changing feature on the PWA (left) and on the native mobile application (right)

In terms of features, the PWA provides advanced features such as Twitter Ads and Analytics which the other application does not. However, the native application supports sharing the profile link via Quick Response code (QR code) and adding voice recordings to the Tweet which the PWA does not. Push notification is also not supported on the PWA while it is supported in the other application.

Storage and installation

As for storage, the native mobile application takes up 123.1 megabytes. Storage taken by the PWA is not measured because it is a web application. As for installation, the native mobile application requires going to Apple's App Store or Google's Play Store for downloading. The PWA, on the other hand, requires adding the application icon to the home screen by visiting the Twitter website in the browser.

4.2 Data collection

Six respondents participated in the usability tests and interviews of this research. During the usability tests, potentially interesting observations were noted and would be displayed below.

4.2.1 Respondent 1

Respondent's basic information: between 20 and 25 years old. Knows about Twitter. Has used the Twitter mobile application before.

Respondent 1 chose the native mobile application to do tasks first. As he was familiar with the Twitter native mobile application before, doing tasks was easy for him. The respondent also finished the tasks on the PWA quickly using the same steps with the native mobile application. While checking the PWA, he noticed the differences in the sidebar. He stated that the PWA seemed to have more options. He thought the sidebar in the PWA contained everything, while the sidebar in the native mobile application only had a few options. However, he thought that the native mobile application was smoother.

At first, the respondent preferred the second application (the PWA) because it seemed to have more options. Interestingly, he also thought his preferred app was the native mobile application, and the other was the PWA for the same reason.

When exposed to some limitations of the PWA such as no push notifications and fewer effects when taking photos, the respondent changed his decision to prefer the mobile native application. He stated: "those features are convenient. Being notified when there is new information."

4.2.2 Respondent 2

Respondent's basic information: between 20 and 25 years old. Knows about Twitter. Has not used Twitter before.

Respondent 2 chose the PWA to do tasks first. The first two tasks were done quickly. However, she had difficulties finding the setting for changing the background from the sidebar. She stated that it had too many options so she could not know what to choose.

Interestingly, she mentioned the language used in the native mobile application for tagging people in an image - "Who's in this photo?" text – was old and not cool. For this feature in the PWA, the text reads "Tag people".

When mentioned the data storage advantage of the PWA, she replied that data storage was not a problem. The respondent did not realize any big differences in features, animations other than those mentioned above. She also figured out which one was the PWA and which was the native mobile application after the test.

4.2.3 Respondent 3

Respondent's basic information: between 20 and 25 years old. Knows about Twitter. Has not used Twitter before.

Respondent 3 chose the PWA to do tasks first. She thought that the PWA had features like those of Facebook and Instagram such as posting a Tweet, liking a Tweet, following others, etc.

She quickly finished three tasks on the PWA. When changing the background using the PWA, the respondent stated that there were different colors and a symbol for each of them. She commented that the symbols were cute but the colors they stand for were not related. She suggested that there should be more colors and more themes.

When switching to the native mobile application, she stated that the two applications seemed the same at first sight but quickly realized there were differences. Specifically, she found another faster way to change the background in the native mobile application, instead of going through different settings and sub-settings. She stated that this feature was more visible in the native mobile application. The other application took more steps to change the background. The respondent also realized there was a recording option when creating a Tweet in the native mobile application and there was not in the PWA.

In the end, the respondent preferred the PWA. She stated that she was concerned about the storage. The respondent explained that when there were less than five gigabytes of storage, her phone was slow. She would like the applications to take less storage. She also figured out which application was the PWA and which was not.

4.2.4 Respondent 4

Respondent's basic information: between 20 and 25 years old. Knows about Twitter. Has not used Twitter before.

Respondent 4 chose the PWA to do the tasks first. She quickly finished the tasks, saying it was easy to navigate. When switching to the native mobile application, she troubled with finding the buttons for blocking/following a person. She stated it was located at a different

place, harder to see than that of the PWA. Overall, the respondent seemed to prefer the PWA more, saying it had a clearer, detailed design.

When asked which one was the PWA, the respondent thought that the PWA was the native mobile application. When mentioned several limitations of the PWA such as lack of notifications and features, she said she would prefer the native mobile application more. The respondent stated that notification was important. Data storage, however, could be put up with if the application were used occasionally.

4.2.5 Respondent 5

Respondent's basic information: between 18 and 20 years old. Knows about Twitter. Sometimes uses Twitter for work (as a social media marketing trainee).

The respondent chose to do tasks on the PWA first. He thought that he was familiar with the user interface, as it seemed the same as other mobile applications. He finished three tasks quickly on the PWA. The respondent thought that If he checked around the application, he could find a way to do things.

While doing tasks on the native mobile application, the respondent found out a lot of differences between the two applications: no QR code feature, no image suggestions, no recording option, no adding location option when creating Tweet in the PWA, and background changing feature easier to find on the native mobile application. He also pointed out different settings categories between the two applications. On the other hand, he found the button for blocking and following people of the native mobile application was in a less visible area. The respondent stated working in social media marketing made him focus on small details that might affect user experience and lead to abandoning the application.

Interestingly, when doing tasks on the native mobile application, the respondent firmly believed that the first application (the PWA) was not a real mobile application. He stated that the image editing feature was too simple for a mobile application and if it was one, the application should have more features like those of Instagram and Facebook.

Another difference the respondent mentioned was that sweeping in the PWA seems easier than in the other application. The reason is that for the PWA, sweeping to the right means go back to the last visited screen, same as going back to the previous page when browsing a website. Therefore, sweeping is possible for almost every screen. On the native mobile application, this feature is not possible on every screen. It only applies to screens with the back arrow or screens with many horizontal tabs inside.

Finally, he suggested that the PWA should change its designs to be more modern, and put the background changing feature in a more visible place.

4.2.6 Respondent 6

Respondent's basic information: between 25 and 30 years old. Heard of Twitter before. Has not used the Twitter application.

The respondent chose to do tasks with the PWA first. The first task of posting a Tweet with an image took a little time. However, after she finished it, she got used to the application and quickly finished the two other tasks. She stated that it was easy to do the tasks but there were a lot of texts and not so many images.

Switching to the native mobile application, the respondent stated posting a Tweet felt more like posting a story on the Instagram application. Interestingly she found out a fault with the navigation bar at the screen bottom. It was hidden by half and moved up and down when scrolling**.** This problem happened after the respondent used the taking photo feature when posting a new Tweet.

After the test, the respondent figured out which application was the PWA and which one was the native mobile application. She stated that the biggest differences were the user interface and features. She was concerned if there was an update on the application, such as new filters for editing photos, would the PWA also had this update.

4.3 Data analysis and discussions

This section analyzes the data collected from the usability tests and interviews. Section 4.3.1 discusses the respondents' attitudes about user interfaces. Section 4.3.2 aims at respondents' attitudes about the features. Section 4.3.3 proceeds to discuss the respondents' preferences and their reasons.

4.3.1 Respondents' attitudes about the user interfaces

For the user interface, the differences in the design and in how the two applications respond were most noticed. Specifically, in the sidebar, the PWA displays each option in one line and has a title for each one. The native mobile application has the same approach but uses icons without titles for specific options (background changing, QR code sharing, etc.) and place these icons in the corners of the sidebar instead of on the lines. Two out of six respondents stated that they liked the detailed sidebar of the PWA. Respondent 1 commented that the sidebar of the PWA contained a lot of options, while that

of the native mobile application only had a few options. Respondent 4 agreed and stated that the PWA's sidebar made every option clear. She thought the sidebar of the native mobile application was too simple and she might not find a feature when she needed it. On the other hand, respondent 2 complained that the PWA's sidebar had so many options, making her confused and did not know what to choose. Respondent 3 agreed and stated that using the PWA's sidebar, she took more steps to change the background color, while using the native mobile application's sidebar, she could do it faster as the feature was more visible by the icon. Respondents 3 and 6 also felt that the native mobile application's sidebar made common settings more visible, therefore changing these settings was simpler and faster. Also, about the difference in features' location, respondents 4 and 5 pointed out the blocking/following people feature on the native mobile application to be not so visible compared to that of the PWA. Respondent 2 could find the logout feature on the PWA while she could on the other application.

Moving on to how the applications respond, almost all respondents pointed out that the native mobile application was smoother than the PWA. The former has more animations, which makes it seems faster than the latter.

Overall, a few respondents appreciated the PWA's user interface for its detailed and explicit design. These respondents criticized the other application's user interface to be oversimplified. On the other hand, respondents who favored the native mobile application argued that this application had a clearer and simpler design. The native mobile application's common settings were made more visible and faster to change. They found the PWA's design having too many details, making the application look confusing. However, most respondents agreed that the native mobile application seemed smoother and faster than the PWA when interacting.

4.3.2 Respondents' attitudes about the features

Almost all the respondents felt that the PWA had fewer features than the native mobile application. Most respondents recognized the lack of image suggestions when creating a Tweet. Two respondents recognized that there was no recording feature when creating a Tweet for the PWA, while it was available in the native mobile application. Only one respondent pointed out that there was a QR code sharing feature in the sidebar and an adding location feature when posting a Tweet on the native mobile application and not on the other application.

Interestingly, this lack of features caused three out of six respondents to consider the PWA to be different from the native mobile applications they were used to. Respondent 6

found that when using the features, the native mobile application seemed familiar to other applications she had on her phone like Instagram as compared to using the features on the PWA. Specifically, she stated that posting Tweets on the native mobile application felt more like posting a story on Instagram. Respondent 5 agreed. He firmly believed that the PWA was not a real application as it lacked the filters and editing tools for taking photos normally found on applications he was used to, namely Facebook and Instagram. Respondent 3 also shared that the two applications seemed 95% like each other but there were minor differences and that the image suggestion when posting Tweet was like that of the Facebook application she was using.

4.3.3 Respondents' preferences and reasons

During the interview, the respondents chose their preferred application. After the interview, more information about the two applications was presented and the respondents were asked again their preferences and reasons for changing if there were any. The answers show what these users consider most important when using the application and how it affects their preferences on the two applications.

When asked about their preference for the first time, three out of six respondents favored the PWA more. Their reasons were that the PWA had a more detailed design and felt more modern, while the other application seemed over-simplified. Respondent 3 stated that the background changing feature on the PWA had more color options than that of the native mobile application. She chose the PWA for this reason. On the other hand, three respondents who favored the native mobile application reasoned that its design was more modern, and the application seemed smoother and faster. They also said that the image suggestion when adding Tweet was convenient, the background changing feature was more visible, and the application felt more familiar with applications that they normally used.

Several differences between the two applications which were not explored during the usability tests were mentioned such as the lower storage needed by the PWA, the different installation method of the PWA, and no support for push notifications on the PWA. Respondents who favored the native mobile application did not change their preferences. They stated that the storage was not a problem. Most modern phones had storage of more than 128 gigabytes, and it was more than enough for normal applications, stated respondent 1. Respondent 5 thought that people wanted more features, and they would approve less free storage in exchange for more convenience. He also stated that he was familiar with the normal installation method and would not change. Furthermore, two out of three respondents favored the PWA before also changed their preferences. Respondent 1

stated that notifications were very convenient and important for him. Respondent 4 agreed and stated that if she used the application often, she would not mind the large data storage. Only respondent 3 favored the PWA at the end. She stated that the features on the mobile native application were nice. However, as she did not use Twitter a lot, they were not necessary. The respondent stated that she preferred a small application just to check information rather than posting Tweets.

4.4 Suggestions for businesses

The results show that while three out of six respondents favored the PWA at first, only one respondent maintained her preference at the end. While this result might seem discouraging, the study also found out evidence supporting the PWA. This section first goes through these pieces of evidence. Based on them, different ideas for changes are suggested. Finally, the study suggests different use cases for the PWA.

Four out of six respondents have used the Facebook website on their mobile phone instead of the Facebook application at some point. These experiences were specific for the Facebook web application but can also be considered for the PWA as well. Respondent 6 has used the Facebook website only because of her phone's limited storage. Respondent 5 once deleted his Facebook application to prevent distraction while studying and use the Facebook website instead. He stated that the Facebook website for the mobile phone was irritatingly slow and he must download the application again. Respondents 3 and 4 also used the Facebook website, but switched to the Facebook application later as on its website, Facebook suggested using the application for a better experience. These pieces of evidence present different cases where the mobile browser platform is used but fails to meet the users' expectations. Together with the earlier findings, reasons for these abandonments can be defined as the lack of features, especially push notifications, the less pleasing design, fewer animations, and recommendations of Facebook to use the native mobile application instead.

With these reasons defined, the study suggests some ideas for change. Notifications can now be implemented for the mobile web application. However, there are technical support issues. While not all features available on the native mobile application are supported on the website, the website's design can be changed for a more app-like experience. More animations when interacting can make the application seems more responsive, smoother, and faster to use. Another change is about how businesses make use of the mobile browser platform. The business can introduce the web application as a demonstration for their native application and suggesting the native application for a full experience.

Lastly, several interesting use cases for the PWA that emerged from the interviews of this research are presented. Installing different PWAs on the same mobile phone for different social accounts is one of them. Also, the PWA can target users with basic needs or limited storage. Overall, using PWAs side by side with the native mobile applications can increase customers' reach for businesses.

5 CONCLUSIONS

5.1 Key findings

This chapter summarizes and concludes the thesis. Section 5.1 highlights the key findings of the research. Section 5.2 then addresses the research limitations. Finally, section 5.3 concludes the study with a few suggestions for future research.

The research found out that features and the user interface are important factors when the respondents choose between the PWA and the native mobile application. The results showed that:

- One main reason for users to choose the PWA is its design.
- Most users feel that the native mobile application is smoother than the PWA.
- The main reason for switching from the PWA to the native mobile application is the lack of features, such as push notifications, filters, and editing tools for taking photos.

The research emphasizes the user interface design's importance when one user chooses between these two types of applications. While not all features available on the native mobile application are currently ready on the PWA, the PWA's design can be modified to deliver a better experience and finally gains the user's preference.

5.2 Research limitations

Overall, the study managed to explore the concept of the progressive web application, its current capabilities, and support in a format suitable for business use. It also investigated end-users' attitudes towards the PWA. However, there were several limitations, which are discussed below.

Firstly, this research had a small target group and a small sample size, which presented only one small group of end-users and not all end-users. Secondly, only one case in the social media context was studied. For this reason, the respondents may not experience fully the advantages of PWAs. The results, therefore, are specific for the Twitter PWA and may not be guaranteed for all PWAs. Another limitation is that the research only applied simple usability tests and interviews. More in-depth tests with tasks that cover more areas of the application would gain better results.

While the pandemic might prevent a large sample size and large target group, having more in-depth usability tests or studying multiple cases instead of studying one case

would greatly help produce more specific results and wider applicable conclusions. The study can also be made stronger.

5.3 Suggestions for future research

Based on research findings, several suggestions were made for businesses interested in the PWA, which can be found in the last section of the Empirical study chapter. For future research, one may explore end-users' attitudes towards PWAs in contexts different from social media and compare the findings. This research also left out case studies of businesses choosing the PWA as their solutions and the results. A look into these studies to investigate the benefits of PWAs from the business perspective or how PWAs are used by businesses can be interesting topics to research.

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APPENDICES

APPENDIX 1. SUMMARY OF THE INTERVIEWS

Respondent 1

1. **How often do you use social media?**

   A lot. About three and a half hours a day.

2. **Name some of the social media you usually use.**

   Twitter, little. Facebook, from one hour to one and a half. Instagram from one to two hours.

3. **Do you use the website or the application to access these platforms?**

   No, 99% of the time I use mobile applications.

4. **Have you used the website to access these platforms on your mobile before?**

   No.

5. **Have you heard of Twitter before?**

   Yes. I sometimes check Twitter, but not every day.

6. **Did you notice any differences in the User Interface when doing the tasks? If yes, what are they?**

   The first application's user interface [the native mobile application] is lame and simple. The second application [the PWA] is more complex. It has more beautiful designs, more modern, and has more options to choose from.

7. **What do you think about these differences? What do you like and dislike about these two applications?**

   Yes. The second application [the PWA] looks complex at first, but when you get used to it, it is more entertaining. The first app looks minimal, so it is boring later.

8. **Which application makes it more difficult to do the tasks?**

   Both are easy to do. The second application [the PWA] seems difficult to use at first but it gets easier later and more comfortable than the first one.

9. **Which application will you use if you are to use Twitter in the future?**

I prefer the second application [the PWA] in the future.

10. After knowing the information, do you have a second thought?

The first app [the native mobile application]. Notifications and filters are convenient when you want to receive updates and news. Storage is not a worry. Most modern phones have more than 128 gigabytes of storage.

Respondent 2

1. **How often do you use social media?**

   Really often. 13 to 14 hours a day.

2. **Name some of the social media you usually use.**

   Facebook, Instagram, TikTok, WhatsApp.

3. **Do you use the website or the application to access these platforms?**

   Mostly with the application on my mobile phone. For the laptop, I use the website.

4. **Have you used the website to access these platforms on your mobile before?**

   No, I hardly use the website because I see that it is very inconvenient.

5. **Have you heard of Twitter before?**

   Yes, I know about it.

6. **Did you notice any differences in the User Interface when doing the tasks? If yes, what are they?**

   I like the second application [the native mobile application] more. It is less overstuffed. The buttons are simple but nice.

7. **What do you think about these differences? What do you like and dislike about these two applications?**

   I do not have anything to dislike in the second application [the native mobile application]. The first application [the PWA] is too overstuffed. It should put these options into only one place, like the second application. However, the logout option on the second application [the native mobile application] is not very visible.

8. **Which application makes it more difficult to do the tasks?**

   The first one [the PWA] is too overstuffed. The second one [the native mobile application] is simpler to do.

9. **Which application will you use if you are to use Twitter in the future?**

   I prefer the second application [the native mobile application].

10. **After knowing the information, do you have a second thought?**

No. It [the PWA] should have fewer options. When I want to change something, there are so many options and it is confusing. Normally, there is only one setting place, and smaller, different options inside this place for me to choose from. It is nicer that way.

Respondent 3

1. **How often do you use social media?**

   Yes. I guess it is a lot, four to five hours a day.

2. **Name some of the social media you usually use.**

   Popular ones like Facebook, Instagram.

3. **Do you use the website or the application to access these platforms?**

   Both.

4. **Have you used the website to access these platforms on your mobile before?**

   Yes. Before I used the Facebook website on my mobile, but when I switched to the application, I feel that it is more convenient. When clicking on a profile link, Safari opens the website but asks if I want to switch to using the app. It suggests that by using the app there are more features and things are nicer.

5. **Have you heard of Twitter before?**

   Yes, I know about it a long time ago, but choose not to use it.

6. **Did you notice any differences in the User Interface when doing the tasks? If yes, what are they?**

   The applications seem the same for 95%. In the second app [the native mobile application], the changing background setting does not have options for changing colors [only dark theme and light theme]. However, it seems easier to do and takes fewer steps. When creating Tweet [the native mobile application], there are image suggestions, quite like that of Facebook. I like this [the native mobile application] more because it is more convenient.

7. **What do you think about these differences? What do you like and dislike about these two applications?**

   I like the color-changing feature [the PWA]. But I want more colors.

8. **Which application makes it more difficult to do the tasks?**

   This app [the native mobile application] seems more convenient as it has image recommendations. However, I like the first application [the PWA] more because there are many colors to choose from.

9. **Which application will you use if you are to use Twitter in the future?**

   I choose the first one. I do not post a lot, so even though the second seems to be more convenient for posting, I like the first one more for it has more colors.

10. **After knowing the information, do you have a second thought?**

    No. Notifications are not mattered to me. If I need to contact someone, I use other applications and not Twitter. I just want to use Twitter for checking the news, so I do not need notifications. Notification is a nice thing to have, however.

Respondent 4

1. **How often do you use social media?**

   Between one and two hours a day.

2. **Name some of the social media you usually use.**

   Instagram, Facebook, TikTok, YouTube.

3. **Do you use the website or the application to access these platforms?**

   Mostly applications.

4. **Have you used the website to access these platforms on your mobile before?**

   Yes. I used the Facebook website on my phone before but switched to the app because it said so.

5. **Have you heard of Twitter before?**

   Yes. But I did not use it.

6. **Did you notice any differences in the User Interface when doing the tasks? If yes, what are they?**

   Yes. The first one's sidebar [the PWA] is more detailed, yet clearer. The second one [the native mobile application] has many little things.

7. **What do you think about these differences? What do you like and dislike about these two applications?**

   [together with the answer to question 8]

8. **Which application makes it more difficult to do the tasks?**

   The second one [the native mobile application] seems simple at first. It has not many choices to choose from, but it makes many features not so visible. It is hard to find these features when you need them. So, it is more complex. The first one's design [PWA] is clearer and more specific.

9. **Which application will you use if you are to use Twitter in the future?**

   I like the first application [the PWA] more. So, I will choose it. I think the second application [the native mobile application] should have a better design.

10. **After knowing the information, do you have a second thought?**

Yes. Notifications are important. So, I switched [to native mobile application]. Data storage is also important, however, if the app is important, then I can put up with that.

Respondent 5

1. **How often do you use social media?**

   Yes. Two to three hours a day. For both work and leisure.

2. **Name some of the social media you usually use.**

   Facebook, Instagram, LinkedIn, Twitter. Slack.

3. **Do you use the website or the application to access these platforms?**

   Both. I use applications on my mobile phone. I use websites on my laptop.

4. **Have you used the website to access these platforms on your mobile before?**

   Sometimes. When I want to detox myself from Facebook, I delete the application. I go for the web to check for something interesting but feel that the user interface to be irritatingly slow. After that, I install the application again.

5. **Have you heard of Twitter before?**

   Yes. My work requires checking that as well. I only check the website on my laptop one or two times a month, however. [On Twitter] About five to ten minutes only.

6. **Did you notice any differences in the User Interface when doing the tasks? If yes, what are they?**

   The second application [the native mobile application] has more features, like image suggestion when creating a Tweet, background setting feature easier to find, a location option when creating Tweet, more filters, and editing tools for image editing.

7. **What do you think about these differences? What do you like and dislike about these two applications?**

   Basically, the two applications look the same. But in minor places, it is different. For example, there are differences in the settings. Normally people change and forget about them, so they do not notice these small differences.

   I think if an app is less in storage but also less in features, sometimes people would not choose it. In case the other app takes more storage but have fewer features, then it is simple to choose the other.

8. **Which application makes it more difficult to do the tasks?**

Doing tasks on both apps is the same.

The second application [the native mobile application] is more convenient. The background changing is right outside. This makes it easier to do the tasks. I like it more. The speed for creating Tweets is almost the same. The second application [the native mobile application] also seems smoother.

9. **Which application will you use if you are to use Twitter in the future?**

   The second app [the native mobile application]. It is more convenient for me. There are more options for me. Filters are important to me. For example, when I post a Tweet with an image, and I want to add a black-and-white filter, the second app [the native mobile application] can do that. The first one [the PWA] cannot.

   Another thing that makes me favor mobile applications more is posting a story with Instagram. You cannot add a story by using a laptop and the website. Also, changing accounts is more difficult on the web. On the application, it is more straight forward.

10. **After knowing the information, do you have a second thought?**

    No. Now phones have a lot of storage. People value convenience more. They want more features, even more than what they needed. They want the best.

    They are also familiar with going to the App Store or Play Store to download apps. And I think it is simple enough and prefer not to change. The same goes for other people.

    I think with this amount of storage and with the features it provides, it is good enough for casual users. But if they need something more, the app is a better choice. Data storage is not really an advantage as most phones now have abundant storage.

Respondent 6

1. **How often do you use social media?**

   Approximately three hours per day.

2. **Name some of the social media you usually use.**

   Most is Instagram. Facebook after that. Also, YouTube. Recently TikTok.

3. **Do you use the website or the application to access these platforms?**

   Both. For Facebook and YouTube, I use the website. For the others, I use the application.

4. **Have you used the website to access these platforms on your mobile before?**

   Yes. I use the Facebook website on my mobile phone. I do not use the application for that because I do not have much storage.

5. **Have you heard of Twitter before?**

   Yes. I heard about Twitter a lot.

6. **Did you notice any differences in the User Interface when doing the tasks? If yes, what are they?**

   I think that I like experiencing the second application [the native mobile application] more. The interface when posting a Tweet, blocking/following people, changing background color feels more familiar to the other applications that I am using.

7. **What do you think about these differences? What do you like and dislike about these two applications?**

   I like the second application [the native mobile application] better. The application seems faster and smoother. There are image suggestions when I am posting a Tweet. After hitting following a person, when I scroll down, I can see their new Tweets already.

8. **Which application makes it more difficult to do the tasks?**

   The second application [the native mobile application] seems faster and smoother.

9. **Which application will you use if you are to use Twitter in the future?**

The second application [the native mobile application]. I like the second more because it feels more familiar with the Instagram application I am using.

10. After knowing the information, do you have a second thought?

Data storage is important. The phone I am using does not have much storage. However, if it is not for the data limitation, I would prefer to use the application. It is smoother, has more features, and is more convenient. I might use the first application [the PWA] if I have two accounts for different purposes.