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PROGRESSIVE WEB APPLICATIONS AND USERS' ENGAGEMENT

Investigating the Impact of Progressive Web Applications on Users` Engagement.

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ABSTRACT

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The world is continuously undergoing digital transformation, with billions of people worldwide owning electronic gadgets such as smartphones and laptops which they use to connect to the internet for different purposes. These purposes could be accessing governmental or organizational services, online shopping, making hotel reservations or flight booking. However, the usefulness of these gadgets relies on users` ability to efficiently access their desired contents through web or mobile applications.

A Progressive web application (PWA) is a new technological advancement in Web Development that integrates the best features of web and mobile applications to provide users with reliable, smooth, and engaging experiences across several devices and platforms.

The aim of this thesis was to investigate the impact of Progressive Web Applications on users' engagement by examining the theoretical foundations of PWAs, technological influences, and the empirical findings linked with PWAs. This thesis provided a comprehensive understanding of PWAs and users´ engagement by identifying key factors that influence users` interaction and retention.

The study used an inductive approach and qualitative methods- including surveys, case study design, and interviews to examine users' attitudes and actions towards PWAs. The research also used secondary data that was gathered by reviewing existing literature on PWAs to gain a broad understanding of PWAs and their present capabilities. In addition to the secondary data, primary data was obtained through surveys, interviews, and usability testing of AliExpress PWA with end users. The study was conducted in two stages. The first part was a general survey on PWAs to evaluate users` impressions about PWAs and the second stage dealt with a case study of AliExpress for an in-depth analysis.

The study from the general survey found that the majority of users are satisfied with PWAs and that PWAs significantly enhance users´ engagement through features like push notifications, ease of use, and responsiveness. These features contribute to higher engagement and retention rates. In terms of preference between native mobile applications and the PWAs, participants during the survey the number of participants who preferred native mobile applications was the same as the number who chose the PWAs. The usability tests and interviews conducted with users of the AliExpress PWA and the native mobile application revealed that about 57% of the participants preferred the native mobile application of AliExpress because of its easy-to-use layout, while about 43% preferred the PWA because it does not require download and installation on their devices. By combining the key findings from both the survey and the usability test, it was discovered that PWAs enhance user engagement and have the potential to change the web development landscape.

Keywords: Progressive Web Application, AliExpress, Engagement, Usability test

ABBREVIATIONS

PWA	Progressive Web Application
HTML	Hypertext markup language
CSS	Cascading style sheet
WWDC	Worldwide Developers Conference
XML	Extensible markup language
AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
HTTPS	HyperText Transfer Protocol Secure
TLS	Transport Layer Security
AR	Augmented Reality
VR	Virtual Reality
TAM	Technology Acceptance Model
UTAUT	Unified Theory of Acceptance and Use of Technology

CONTENTS

1 INTRODUCTION

1.1 Background

As the technology landscape is constantly changing, all sectors most especially businesses are continuously looking for innovative ways to enhance their users´ engagement and retention. For every successful business or online platform, users` engagement is at the forefront. This has led to the development of innovative solutions that enhance user engagement and experience.
Among these developments to provide innovative solutions that enhance users` engagement and experience, Progressive web applications (PWAs) have emerged as one of the leading approaches for delivering a native application-like experience through web browsers.
Progressive Web Applications (PWAs) are the new innovative approach to web development that aims to enhance the web browsing experience by integrating the best elements of web applications and mobile applications to provide users with reliable, smooth, and engaging experiences across several devices and platforms. Progressive web applications are built using traditional web application technologies like HTML, CSS, and JavaScript. As web technologies advance, PWAs are becoming a popular option for developers, businesses, and organizations looking to engage many users with high-performance applications. PWAs are made to run offline, faster, and offer users an experience that is comparable to native applications. This is made possible using features such as service worker, caching, and push notifications which enable PWAs to function even in settings or environments with low connections. (1.)

The convergence of web application technologies has significantly increased users' engagement, resulting in seamless interactions and faster access to content. Many commercial businesses and organizations have adopted PWAs to increase users` experience and engagement. By implementing PWAs, these organization, and businesses can focus on providing users with fast, smooth, and engaging experiences across different devices and platforms (2). Their decision to develop Progressive web applications reflects a broader trend in the development of PWAs, in which businesses utilize these applications to enhance their digital presence and retain users.
This thesis investigates the impact of Progressive web applications on users´ engagement, features, and performance of Progressive web applications to understand how the adoption of PWAs affects users` behaviour.

1.2 Objectives of the research.

The main objective of this research was to investigate the relationship between Progressive web applications and users` engagement. The study aimed to explore how users engage with Progressive web applications, specific elements of PWAs that enhance users' engagement, to understand users' perceptions about PWAs, and identify limitations of PWAs.

1.3 Research Questions

Research questions is the glue that holds projects together, and the research questions help researchers set boundaries for literature review, suggest appropriate methods to be used during the research, and produce more refined results (3). It is therefore important to have good and well-defined research questions. The thesis will address the following research questions:

- What specific features and designs of these PWAs have led to improved users' engagement?
- What are users ` preferences between PWAs and native mobile applications?
- What are the limitations of PWAs?

1.4 Research approach.

To answer these thesis questions, the study used a combination of literature review, and qualitative data analysis through surveys and case study. The literature review gave an overview of PWAs, user engagement, and previous research on the topic. Data analysis provided insight into users` interaction with different PWAs through surveys and case study which examined how the adoption of AliExpress PWA has impacted users` engagement.

1.5 Importance of the research

This research is important for several reasons. Firstly, it contributed to a better understanding of how PWAs have enhanced users´ engagement, offering insights for businesses and organizations

considering the adoption of PWAs. Secondly, the study provided a full evaluation of AliExpress by carrying out usability tests on the PWA and native mobile application. Finally, the research highlighted the present limitations of PWAs and their potential to change the future of web development and users` experience.

The findings of this research would guide businesses, organizations, and developers in implementing PWAs effectively, thereby ensuring an optimal user experience and high levels of engagement. By focusing on AliExpress PWA, this research provides a practical and in-depth evaluation of the impact of PWAs on user engagement, contributing valuable insights to the field of web development and digital marketing. (4.)

1.6 Structure of the thesis

This thesis has been divided into eight chapters, beginning with an introduction, followed by a Literature review, Methodology, Results, Discussion, Conclusion, References, and Appendices.

2 LITERATURE REVIEW

This chapter is divided into several sub-titles, beginning with the overview of PWA, the history of PWAs, followed by the theoretical foundations of users´ engagement, the role of technology in users´ engagement, framework for analyzing users´ engagement, core technologies, and then lastly previous research on PWA and users´ engagement.

2.1 Overview of Progressive Web Applications (PWAs)

PWAs are developed with common web technologies like HTML, CSS, and JavaScript, but they provide features typically associated with native applications. Some of the key elements of PWAs include offline capabilities, push alerts or notifications, and home screen installation. These applications strive to deliver a consistent users´ experience irrespective of network conditions. (5.)

2.2 History of Progressive Web Applications

Progressive web applications are a significant advancement in traditional web programming, combining the finest elements of traditional web applications with native mobile applications. PWAs were initially introduced by Google in 2015, although their roots and technologies that support them have been developing for much longer. The idea was to build web applications that are like native mobile applications while maintaining the broad reach and accessibility of web applications (.6).
This section of the chapter discusses the historical development of PWAs, emphasizing major milestones and technological advances. The transition to PWAs started in early 2000 with the advancement of web technology. Web developers decided to improve the users` experience and functionality of web applications by addressing concerns such as slow loading times, limited offline capabilities, and the lack of native-like features.
Asynchronous JavaScript and XML (AJAX) was introduced in the early 2000s. AJAX enabled web pages to update asynchronously by performing the exchange of small amounts of data with the server in the background. This resulted in more dynamic and faster web applications (7).

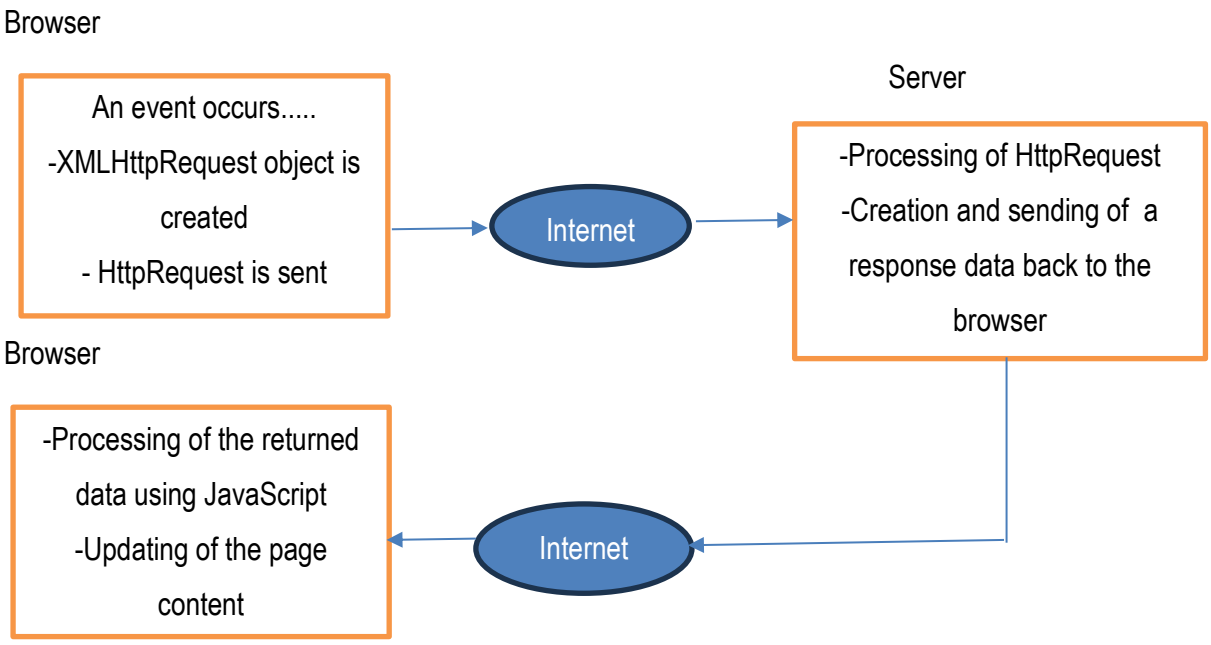

FIGURE 1. The exchange of data between the server and the browser using XMLHttpRequest.

HTML5 and CSS3 came up between 2008 and 2011, and this brought significantly enhanced web development, allowing better multimedia support, more semantic components, and increased performance. This technology was crucial for developing richer web applications with capabilities comparable to native mobile applications (8).

Service workers were introduced in the early 2010s, and they are an important technology of PWAs. They serve as a bridge between the traditional web application and the network, allowing capabilities such as background syncs, offline operation, and push notifications. They enable web applications to cache resources and deliver a more dependable experience even in the absence of an internet connection or poor internet connection. (1.)

In 2015, the term "Progressive Web Application" was brought up by Google engineers, Alex Russell and Frances Berriman. They defined PWAs as web applications that take advantage of modern web features to give users an app-like experience. The following key characteristics were laid out:

- **Responsiveness**: The applications should fit any form, that is they should work seamlessly across different devices and screen sizes.
- **Connectivity independence**: Applications should work whether there is a poor internet connection or not.

- **Application-like interactions**- applications should mimic native and web applications.
- **Fresh**- applications should remain updated.
- **Safe-** the application should be served via TLS, a service worker requirement to prevent snooping.
- **Discoverable-** applications should be searchable on the web browser.
- **Re-engageable-** applications should provide push notifications**.**
- **Installable-** can be added on the device`s home screen with the icon.
- **Linkable-** applications can be shared via links.

From the above PWAs attributes that were enumerated by Alex Russel and Frances, it is clearly seen that PWAs have inherited the best elements of both web and native applications, and this gives users the ability to enjoy app-like experiences without necessarily spending time to download applications in their electronic devices (6).

FIGURE 2. Features of PWAs (32)

Figure 3. The Milestone in progressive web application development (7).

Progressive web application was introduced by Google. Chrome developers, Alex Russel and Frances Berriman in an article that provided a shift in the understanding of developers and the tools to develop better applications across different devices and the concept of using a single codebase. Google and Microsoft were the biggest players that promoted the concept of PWA as a way of serving as a bridge between web and native applications. Google provided the first hint in 2006 and many companies saw a great opportunity for their growth and chose to experiment with PWAs. (7.)

Early adopters of PWAs were Alibaba, AliExpress, Forbes, Twitter, Flipkart, and some other leading web companies. These companies recorded great success and great improvement in users` engagement and performance metrics as seen in Figure 3 (7).

FIGURE 4. Shows the performance metrics recorded by the early companies that adopted PWAs (7).

PWAs are being implemented across different industries, including e-commerce, media, education, and healthcare. This widespread adoption is being driven by the demand for quick, dependable, and entertaining web applications that can reach a large number of people (8).

The integration of PWAs with developing technologies like augmented reality (AR) and virtual reality (VR) creates new opportunities for innovative engaging and interactive users' experiences. These advances are expected to increase the popularity and capabilities of PWAs in the future. (9.)

2.3 Theoretical Foundations of Users` Engagement

Users` engagement is an important concept in the study of users' behaviors and interactions with PWAs. It describes to what extent users get engaged, attentive, and active when using PWAs. Several theories and models have been suggested to explain users` engagement. These are Flow theory, Expectancy value theory, and Self-determination theory. Each of these theories provides a distinct viewpoint on user engagement and helps in finding things that can improve users` experience with PWAs. (10.)

2.3.1 Flow theory.

Mihaly Csikszentmihalyi`s Flow theory states that when people are fully involved in an activity, they experience a state of flow, which leads to increased enjoyment and engagement. This state of flow is characterized by a balance between the activity`s difficulty and the individual`s skill level, clear goals, immediate feedback, and a sensation of control over action. (5.)

In the case of PWAs, creating seamless and intuitive user experiences can help achieve flow in PWAs. For example, quick loading times, seamless transition, and responsive interactions can reduce friction and keep users interested and engaged. PWAs can increase the possibility of users entering a state of flow by guaranteeing that their tasks can be completed easily and with immediate feedback (11).

2.3.2 Expectancy Value Theory

Expectancy-value theory was initially proposed by Eccles and Wigfield. This theory states that users are more likely to interact with an application if they perceive its worth and expect to gain from its use (10). This theory highlights two key components: expectancy, which is the confidence that one can perform the task, and the second component is value -which is the perceived importance or advantages of the task.

For PWAs, this involves increasing user engagement by explicitly displaying the application's value and benefits. Offline capabilities, push alerts, and app-like experiences all help increase

PWA`s perceived value. Furthermore, ensuring that the program is simple to use and offers a smooth user experience will boost users` expectancy of successful interactions, therefore improving users` engagement. (11.)

2.3.3 Self-determination theory (SDT)

Self-determination theory, developed by Deci and Ryan, focuses on the role of intrinsic desire in influencing human action. SDT identifies three psychological needs that must be met to foster intrinsic motivation and engagement: autonomy, which is the act of taking control of one's actions; competence, which is a feeling of effectiveness in one's activities; and relatedness, which is the need to relate to others. (12.)

PWAs can benefit from SDT by giving users more control over their experiences, making it easier to master tasks, and promoting a feeling of community. For example, PWAs can include customized interfaces and settings that can allow users to adjust their experience to their taste and meet the desire for autonomy. Again, PWAs can boost users` perception of competence by providing straightforward features to help them achieve their goals more efficiently. Introducing social features like user profiles, sharing choices, and community interactions can meet the requirement of relatedness, thereby increasing users´ engagement. (12.)

2.4 The Role of Technology in users` engagement

The usefulness of PWA in engaging users heavily depends on the underlying technologies that enable their advanced capabilities. Technology plays an important role in shaping users' engagement. This section examines the essential technological components that improve users` engagement in PWAs. The subsequent paragraphs below give features of PWAs that can boost users` satisfaction and keep them engaged.

Responsiveness and performance are among the main factors that contribute to users' engagement with PWAs. Technologies like service workers and caching strategies are very useful in the responsiveness and performance of PWAs. Service workers enable features such as offline functionality, background sync, and push notifications. They also ensure that the application loads faster and functions in low or no network environments (1). This reduces waiting

times and can keep users engaged. Effective caching enables PWAs to store important assets locally, resulting in faster load times and a more consistent user experience. This is important for engagement, as users are less likely to exit a slow-loading application (13).

Personalization and customization increase users' engagement by providing experiences best suited to their tastes and needs. PWAs can use users´ data to provide personalized content and recommendations. By analyzing users' behavior and preferences, PWAs can provide relevant information, offers, and features that increase users' engagement and happiness (13). Also, a customizable interface that allows end-users to modify their interface and settings can increase their sense of control and autonomy, which is essential for engagement. Features such as themes, layout tweaks, and personalized notifications help create a more engaging user experience (14).

Interactivity and multimedia are important for delivering interesting and immersive user experiences. Adding interactive features such as animations, transitions, and responsive feedback can enhance the user experience. Interactive features keep users engaged and encourage them to spend more time using the application (12). In addition to adding interactive features, the use of multimedia materials like audio, videos, and photographs can increase the attractiveness and engagement of a PWA. Rich media content can enhance the user experience, making the application more appealing to end-users (8).

Push notifications are one of the effective ways to re-engage users and keep them informed about updates, special offers, and essential information. Push notifications allow PWAs to provide timely and relevant updates directly to users' devices, even when the application is not actively being used. This promotes constant engagement by reminding users of the application's presence and value. (14.) User-centric notifications, which are personalized push alerts based on the user's behavior and preferences, can greatly boost engagement. Users are more likely to act on notifications they perceive to be relevant and useful, leading to higher levels of engagement (15).

Application-like experience, PWAs integrate the best features of web and native applications, which are important for users´ engagement. For instance, PWAs can be added or installed directly on users' home screens, bypassing the app store. This simplicity of access, along with the option to easily open the application immediately from the device's home screen, creates a user experience similar to using a native application, which users may find more engaging (16). Additionally, PWAs can run in full-screen mode, giving users an immersive experience without the

distractions of browser controls. The app-like navigation and interactions make PWAs feel more integrated and intuitive, increasing user engagement (2).

2.5 Framework for Analyzing PWAs and Users' Engagement.

To fully assess the impact of Progressive Web Applications (PWAs) on users´ engagement, a multidimensional approach is required. This framework should include evaluation of PWA features, measurement of user interaction metrics, gathering user feedback and satisfaction, conducting case studies and comparing analysis, and carrying out longitudinal research. Each component provides a unique perspective on how PWAs improve users´ engagement.

2.5.1 PWA Features

Understanding the different features of PWAs that contribute to users´ engagement is essential for this methodology. These features include offline capabilities, which are useful for maintaining participation in areas with unstable internet connections (9). Push notifications play a significant role by sending timely updates and reminders, even while the application is not in use, greatly improving user retention and engagement (15). Additionally, the app-like experience that PWAs provide, through home screen installation, full-screen mode, and smooth navigation, helps to increase user happiness and engagement. The app-like behavior encourages users to engage with the PWA frequently (16).

2.5.2 User Interaction Metrics

Quantitative measurements are vital for determining how users interact with PWAs. These include session duration, which measures the amount of time users interact with the PWA in a single session, and this serves as a key metric of engagement. Longer session durations often indicate more user engagement and satisfaction (8). Bounce rate, which measures the percentage of users who abandon PWAs after viewing only one page, and it indicates the application's initial attraction and usability. Lower bounce rates suggest higher engagement (16). Repeat visit counts the number of times users return to the PWA, and this assists in determining

long-term engagement and loyalty. Higher repeat visit rates indicate that users value the PWA (10).

2.5.3 User Feedback Satisfaction

Collecting and analyzing user feedback is essential to understanding the subjective components of users´ involvement. Surveying users´ thoughts on various elements of the PWAs, such as usability, functionality, and overall happiness, gives qualitative data to supplement quantitative measurements (12). Application store reviews and ratings for PWAs provide significant insights into user satisfaction and areas for improvement. Additionally, in-depth user interviews offer deeper insights into customers' experiences, preferences, and pain points, helping to identify specific areas for improvements. (11.)

2.5.4 Case Study and Comparative Analysis

By analyzing specific case studies and comparing Progressive Web Applications (PWAs) to other types of applications can provide valuable context for understanding the impact of PWAs. Detailed case studies of successful PWA deployments can highlight best practices and specific features that increase engagement. For example, studying e-commerce PWAs that have significantly boosted users´ engagement offers helpful insights into the effectiveness of PWAs. (12.) Additionally, conducting a comparative analysis between PWAs, native mobile applications, and traditional web applications makes it easier to discern the distinct advantages and potential limitations of PWAs. This comparative analysis might explain why users prefer PWAs over other types of applications. (15.)

2.5.5 Longitudinal Studies

Tracking users´ involvement over time provides valuable information on the long-term effects of implementing Progressive Web Applications (PWAs). Analyzing engagement data over time can reveal trends and patterns, such as seasonal fluctuations or the impact of new feature launches. This longitudinal data is relevant for understanding how users´ involvement evolves (8). Long-term studies can enable the tracking of retention rates, which indicates the percentage of users who continue to use the PWA over time; and churn rates, representing the percentage of users

who cease or discontinue its usage. These measurements are essential for assessing the sustainability of users´ involvement. Furthermore, behavioral analysis, such as examining changes in users´ behavior such as variations in feature usage or interaction patterns, can give insights into users' requirements and preferences over time, providing valuable guidance for future improvements. (14.)

2.6 Core Technologies of Progressive Web Applications

Technical support is one of the key factors that businesses and organizations take into consideration when selecting technologies for their products. This is because technological support has serious implications for the development process of the product. The selection of the appropriate technologies is often determined by factors such as compatibility, feasibility, suitability, security, ease of debugging and maintenance, cost, ease of scalability, etc. PWAs are no exception to regarding the selection of technologies. This section of the chapter examines the core technologies of PWAs.

2.6.1 Web app manifest

Web application manifest is a file in JSON format that runs in the background and gives information about a web application. It contains the following information such as uniform source locator (URL)- which is the starting point when an application is launched by the user, web application`s name, and application icon (18).

Web application manifest is useful because it controls the browser on how the PWA should appear and behave. For an application to be PWA, it must be installable and for this to happen it needs to have a web application manifest. Below, is the example web manifest code (18):

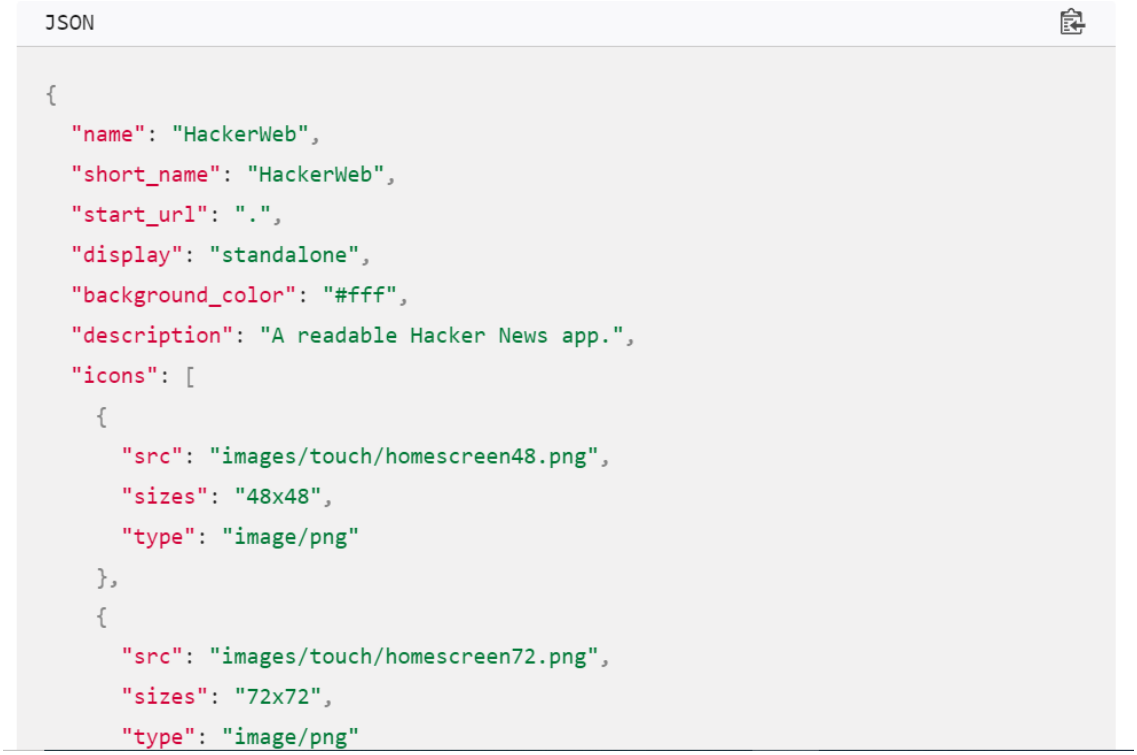

FIGURE 4. Web app manifest codes (18).

Again, developers can use web manifest for customization of the application to display full screen just the same as native mobile applications. This could be either in a portrait or landscape and better mobile application experience. (19.)

PWA support has grown over time in most web browsers like Chrome, Firefox, Safari, and Edge. This extensive support has been critical to the acceptance and effectiveness of PWAs. The W3C has also been instrumental in standardizing the technologies and APIs that support PWAs, like the Service Worker API and the Web App Manifest (1).

The table below shows the different mobile browsers that currently support web manifest. The level of support is the summary of a few properties of the web manifest across various browsers. As can be seen in the table, Samsung Internet and Chrome have the most web application manifest. Opera for Android does not have most of the support for the web application manifest properties that are listed.

TABLE 1. Web application manifest`s support on browsers (18).

Properties	**Description**	**Chrome (Android)**	**Samsung Internet**	**Firefox (Android)**	**Opera (Android)**	**Safari (iOS)**
Background-color	This is the background-color when the application`s stylesheet is not yet ready	Support	Support	Not known	Support	Not support
display	This determines mode that is preferred for viewing the application	Support	Support	Support	Not support	support
name	This displays the name of the application to the users	Support	Support	Not support	Not known	Support
icons	These are icons for displaying the application on the home screen	Support	Support	Not support	Not known	Support
theme_color	Theme color controls how the site is being displayed.	Support	Support	Not support	Not known	Support
short_name	It is used to display to the users when there is not enough space	Support	Support	Not support	Not known	Support

2.6.2 Service workers

Service workers are simply scripts that run in the background and give PWAs the privilege to run on a slow connection or offline. Service workers as the name implies, they respond to events such as network requests made from the pages they serve and have a short lifetime, that is they are only active when there is an event to process. Service workers also create the possibility for PWAs to run different features for example sending push notifications without the web page or users` interactions (20).

MDN contributors describe a service worker as proxy servers, browser, middleman, and the network. Because service workers can interfere with requests, they can act depending on the network situation. For instance, they choose to update and load resources from the cache depending on the network situation, that is when there is no available network, resources are loaded from cache and updated when the network becomes available, thereby creating an effective offline experience. (18.)

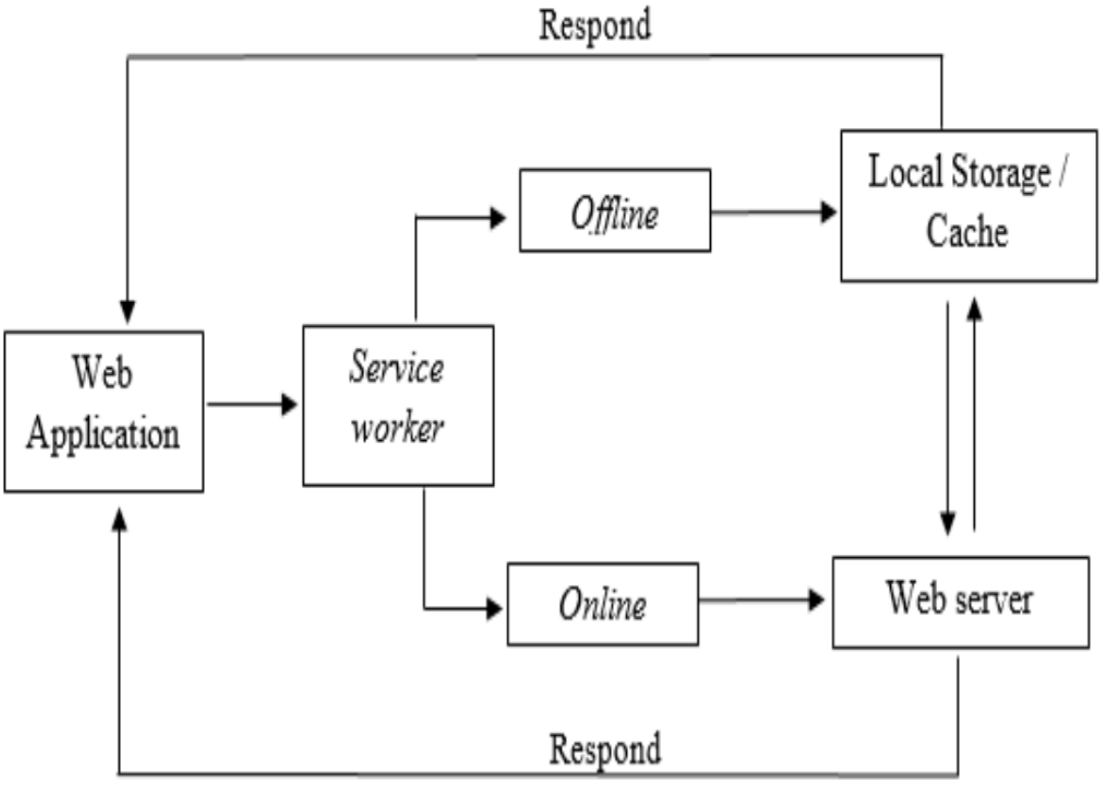

FIGURE 5. Shows how service works both offline and online (33)

2.6.3 Application shell

An application shell is a design that stores static contents of an application like the navigation bar, home page together with other resources which remain the same across the application. This helps provide a skeleton of an application any time an offline request is being made. This feature ensures that the application loading time is reduced and continues to reduce as the users revisit the web application. (18.)

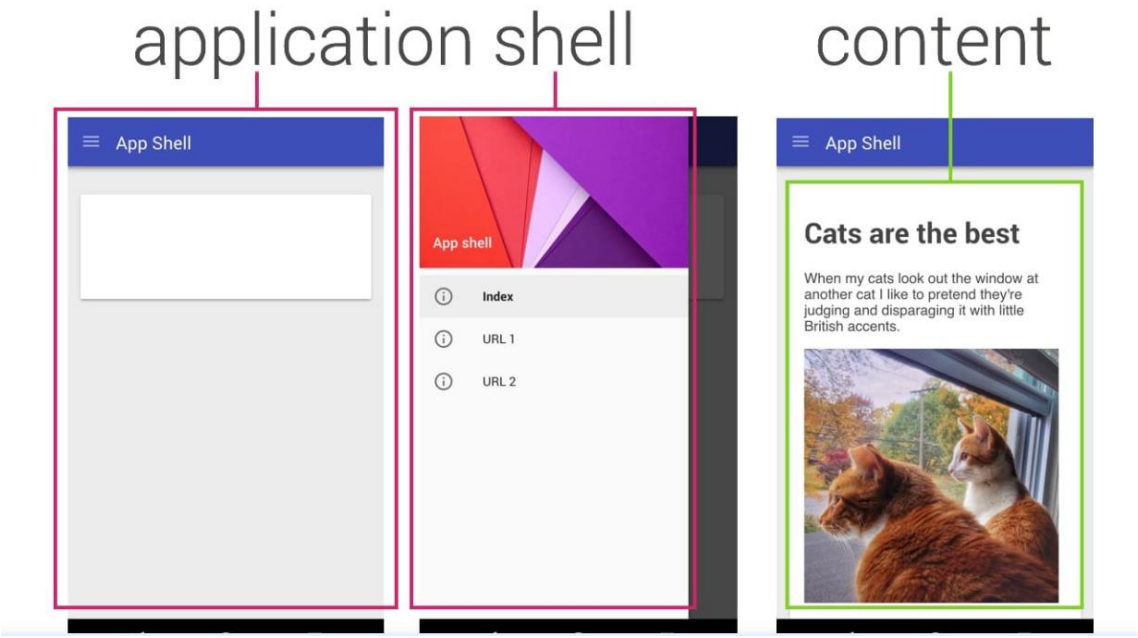

FIGURE 6. An illustration of an application shell and its updated content

2.6.4 Push API

Push API is responsible for updates and push notifications to users. It gives web applications the capability to get push notifications from the server irrespective of whether the application is currently loaded or in the foreground on a user agent. This enables developers to send asynchronous notifications and updates to end users of the application, resulting in better engagement with new content. (18.)

It is worth noting that push API works together with the service worker. This means that for an application to get a push notification, the service worker is supposed to be active and when active, the application can subscribe to push notifications.

According to Medley (21), adopting the use of push API makes it easier for companies to re-engage end-users of the applications, and with this, users can always get new updates in their favourite applications.

2.7 Previous research on Progressive Web Applications and Users` Engagement.

As more companies employ Progressive Web Applications (PWAs) to boost their digital presence, research into their influence on user engagement has increased significantly. Several studies have investigated various aspects of how PWAs affect user behavior, satisfaction, and overall engagement. Some key findings and results are analyzed in the paragraphs below:

Research carried out on “Increased user retention rates” by Smith and Jones in 2022 discovered that PWAs can improve user retention by up to 35%. This improvement is attributable to features such as offline access, which permits users to interact with the application even when they do not have an internet connection, and fast loading speeds, which improve the overall user experience. The study stressed the importance of PWAs' seamless and constant performance in maintaining user engagement over time. (16.)

Patel and Nguyen conducted research on “Enhanced User Satisfaction and Longer Session Durations” in 2023, and discovered that the immersive, app-like experience given by PWAs results in longer session durations and higher user satisfaction. Users appreciate the responsiveness and smooth interactions provided by PWAs, which imitate the functionality of native apps but do not require downloads or installations. (9.)

Positive Impact on E-Commerce Engagement: Gomez and Patel in 2022 investigated e-commerce sites and discovered that PWAs greatly increase user engagement by providing fast load times and efficient performance. According to the study, these variables minimize bounce rates and enhance the possibility of consumers making purchases, which directly benefits online businesses. (8.)

Improved User Experience and Re-Engagement: Smith and Lee in 2023 found that PWAs greatly boost user satisfaction by allowing for seamless transitions between online and offline modes. Push notifications, a crucial feature of PWAs, have been shown to play an important part in re-engaging consumers and keeping them informed about updates, promotions, and new material (15).

2.7.1 Gaps in Literature

Despite the rising number of research in PWA and User Engagement, the following gaps exist:

Industry-specific impact, only a few studies have looked into how PWAs improve user involvement in various areas, including healthcare, education, and entertainment. The majority of existing research is focused on e-commerce and general web applications.

Demographic Variations, there is a scarcity of specific research on how various user demographics like age, gender, and geographic area interact with PWAs. Understanding these changes might help to tailor PWA features to various user groups.

Long-Term Engagement, few research has investigated the long-term effects of PWAs on user engagement after the initial adoption period. Longitudinal research is needed to determine how user involvement with PWAs changes over time.

2.7.2 Contradictions and Inconsistencies.

While most studies point to the benefits of PWAs, there are some contradictory findings as follows: Purchase retention: Smith and Lee in 2023 discovered that PWAs increased purchase intentions on e-commerce platforms. However, another study by Kim and Lee in 2021 found no significant change in purchase intentions when comparing PWAs to native apps, implying that the impact of PWAs may vary depending on context and execution. (15.)

User preferences: While many users value the advantages of PWAs, some research suggests that certain user segments still prefer native apps for specific activities, such as advanced gaming or high-security financial transactions (15).

3 METHODOLOGIES

3.1 Research Design

As mentioned earlier at the beginning, knowing end-users' behaviors towards PWAs is beneficial for businesses and organizations seeking to maximize their potentials. Based on this understanding, the study was created to examine the end-users' perceptions of the PWAs, including what they like and dislike about them compared to native mobile applications. This chapter describes the research approach, strategy, design, methodologies, and justification for these selections.

Inductive and Deductive are the two principal research approaches (3). The inductive approach also known as the empirical approach is a process of developing theories. This approach begins with studying specific occurrences and trying to identify patterns at the end. A deductive or rational approach is a theory-testing process (22.) This process evaluates theories to determine if they apply to the instances under investigation or research. Considering that, this research was aimed to investigate users' sentiments about PWAs, the inductive approach is best suited for this purpose.

3.2 Research plan

During this research, the research approach was first chosen, and then the research plan. According to Wilson (3), there are two research strategies: qualitative and quantitative. Qualitative data deals with non-numerical data that is descriptive and is obtained through methods such as observations, surveys, or interviews. The quantitative method on the other hand has to do with numerical values which may be measured and analyzed statistically. This data is often gathered through structured surveys or existing databases. Hyde explains that quantitative method describes a population's broad traits while the qualitative method describes specifics. He also states that qualitative methods enable researchers to have a thorough study of issues and data collection is limited to predetermined categories. (22.)

This research sought to collect end-users feedback on different PWA features and other factors that may affect their perceptions. Based on this, the qualitative method was therefore more

suitable because the qualitative method is more flexible and adaptable, which allows researchers to easily adjust their approach. Secondly, the qualitative method allows an in-depth study of issues and it is exploratory in nature especially in cases where little is known about the case under investigation. (22.)

3.3 Research design

The term “research design" is a detailed structure for the research process (3). According to Wilson, selecting a research design increases the chances of achieving research objectives. It is therefore important that before conducting research, an appropriate research design should be selected. There are different research designs such as case study, experimental, cross-sectional, longitudinal study, correlational study, etc.

This research made use of a case study. A case study deals with an empirical method that is designed to investigate a phenomenon or situation in depth and within its real-life context, especially when the distinction between the phenomenon and context may be unclear (19). Case study research can focus on single or multiple cases. A single case study is mainly useful for carrying out detailed research before expanding the research to many cases. Multiple cases have to do with the examination of many instances of analysis that fall within the same study. Multiple cases can yield more reliable research findings.

This research was carried out in two parts. In the first part a survey on many Progressive Web Applications was conducted to gauge users` perceptions about PWAs and their preferences between PWAs and Native mobile applications and the second part dealt with a case study of one of the PWAs to facilitate an in-depth study of its application and the end users` engagement and experience. The reason why this research was carried out in two parts was to get a comprehensive understanding of overall users` attitudes and level of engagement towards PWAs. Considering time constraints, this research mainly focused on a single case study because research cannot be conducted on each PWA.

AliExpress commercial application was selected for the case study because it is one of the early companies that adopted PWA. Besides, it is popular and available in both PWA and native mobile applications. This selection made it easier for direct comparison between the two applications during the usability test.

3.4 Data Collection Methods

Two types of data collection methods were used in this research, which included the primary and secondary methods. Secondary data are existing data that have been collected, studied, and published by other researchers. Sources of these data could be from the government, reports, databases, academic journals, etc. These data are cheaper to access and time-saving. As for the primary data, they are new data collected by researchers through interviews, surveys, experiments, or observations. These data are specifically obtained by researchers for their study or research. Because primary data are collected directly from the users or source, they are more relevant, accurate, and unique.

Secondary data was used in the second chapter to understand the concept of PWAs, and their present capabilities and primary data was obtained through general surveys on some PWAs, usability tests, and interviews with the end-users of AliExpress.

3.4.1 General Survey Design on PWAs

This survey was carried out to understand the overall perceptions of users of PWAs. Participants in the survey were made up of different age groups between 18 and 50 years old and from different countries. In the general survey, a survey form was sent out to participants. Before answering the survey questions, participants were told that their personal information would be protected and not disclosed. They were also assured that the answers entered in the survey form would only be used for research purposes in accordance with the data privacy and security standards. Interested participants granted their consent by checking the box and proceeded to answer the survey questions.

In summary, after defining PWAs for participants, they were asked if they had ever used PWAs, and if yes, they were asked to select from a list of PWAs or write down the PWA if not found on the list. The survey questions included the following:

-How easy they find the application to use

-How the functionality of PWA meets their expectations.

-Responsiveness of PWA across multi-sized devices such as loading speed.

-To what extent does PWA provide personalized experiences compared to their preferences

-How interactive they find the features and content within the PWA.

-Level of social integration within PWA, such as the option of sharing content.

-How useful is the offline functionality.

-How PWA was discovered.

-If they have ever added device`s home screen for easy access.

-How useful they find adding PWA to the device`s home screen.

-How often push notifications are received.

-If the push notifications are useful.

-If the push notifications have influenced their engagement with PWA.

-How satisfied are they with the overall engagement features such as push notifications and offline functionalities.

-If PWA can be recommended to others based on its home screen adding feature.

-How satisfied are they with feedback and support within PWAs

-Participants are asked to rate their overall satisfaction using PWA on the scale 0 (very dissatisfied) to 10 (Very satisfied)

In the last part of the survey, the native mobile application was defined, and participants were asked if they had ever used the application before. If yes, they were asked if they prefer PWA or native mobile applications and asked to state the reasons for their preference. Lastly, they were asked to write down what they liked and disliked about PWAs.

3.4.2 Usability test design on AliExpress applications

Goodman defined usability test as a structured interview which is focused on particular features in an interface prototype (4). The usability test focuses on the tests that are performed by the interviewees on a series of tasks. During the tests, notes of the interviewees or respondents were recorded which would be analyzed to understand the way people feel and understand the designs. According to Goodman, this method examines how people perform particular tasks and may not be suitable for studying the overall experience with a product. To address this limitation, particular tasks that cover the application`s main features were selected. In addition to this, the research also conducted a general survey on some common PWAs to get a general insight into end-users' perception of PWAs, and in the usability test, respondents performed the same tasks using both the progressive web and native mobile applications separately. This helped provide an in-depth overview of PWAs, perceptions, and preferences of users in comparison with the native mobile application. (28.)

The usability test was conducted in two parts: the first part was a brief interview, followed by the second part, which involved the tasks and the scenarios. Before the start of the usability test, participants were asked to grant their consent for the recording of the interview and were assured that their data would be protected and not disclosed in accordance with the data protection and security standards. Table 1 shows the brief interview carried out before the usability test and table 2 displays the usability test.

TABLE 2. Brief interview

1	Have you ever used a commercial website or application before? (How many hours per day)
2	List some of the commercial websites or applications you use or have ever used before.
3	How often do you access this/these commercial website(s) or application(s)?
4	Do you usually use or did you use the website or the application of the platform(s)?
5	Have you ever used the website to access the platform on your mobile device example, telephone?
6	Have you ever used or heard of AliExpress before?

After the brief interview, the respondents were asked to prepare for the usability test, and they were given two phones for the test. The respondents or participants were instructed to perform tasks on the website and the mobile application separately. One phone was used to access AliExpress through the website, and the second phone was used to access the native mobile application. Between the two platforms, respondents were asked to choose which one they would like to perform the task first.

TABLE 3. Usability test of AliExpress.

	The task to be performed	**Test to be carried**
1	Product search and discovery	Imagine that you want to buy a pair of wireless earphones between 10 and 20 euros. Search for a pair of wireless earphones within this range and add to your shopping cart.
2	Product listing and details	Assume that you want to buy a backpack for traveling. Search different backpack options, read reviews, and select the one that interests you most and add it to your shopping cart.
3	Adding to cart and checkout process	Let us assume that you have decided to order a smartphone cover for your phone, search, and add the selected cover to your shopping cart, proceed to checkout, and then stop.
4	Account management	Assume that for some reasons you want to update your address in the AliExpress account, go to the account profile and update the address.
5	Navigation and interface	After updating your address, navigate to the cart to view the selected products, and then navigate back to the home page to explore an ongoing promotion.

3.4.3 Interview design on AliExpress applications.

In addition to the brief interview at the beginning and the usability test, respondents were interviewed after the usability test to gather their opinions on the PWA and the native mobile

application. Wilson identifies three types of interview methods, including structured, unstructured, and semi-structured interviews (3).

A structured interview deals with a strict set of questions that require brief answers from the respondents. The shortcoming of this method is that it may not give respondents the opportunity to elaborate on their answers and because of this, interesting data may be lost. In contrast, an unstructured method or in-depth interview begins with broad questions and respondents can be engaged in open-ended discussions. One of the disadvantages of this method is that inconsistency may occur in answers and there is a risk of respondents going off the subject. (3.)

This research explored semi-structured methods. A semi-structured method is a quantitative research approach that incorporates aspects of both structured and unstructured methods. The interviewer has predetermined questions on the subject to cover, but in addition to this, they have the flexibility to explore other areas of interest as the interview progresses. This method offers a balance between the rigidity of the structured method, which may limit exploration, and the unstructured method which may result in inconsistencies or lack of focus.

TABLE 4. Interview Questions

	Questions
1	While using the two applications, did you realize any difference(s) in the layout interface? If you realized any differences, what are they?
2	What are your feelings about these differences?
3	What are the things you like and dislike about these two applications?
4	Which of the applications makes it easier or difficult to perform tasks?
5	Which of the applications do you prefer using or can recommend to a friend?

At the end of usability test and the interview, the respondents or the interviewees were told the advantages and disadvantages of both applications and asked which application they prefer or can recommend to a friend, and their responses were noted down.

3.5 Research sampling method.

In this research, the sample size for the general survey conducted on PWAs to get end-users overall perception about PWAs was planned to be between 50 to 100 at the beginning. Survey questions were shared with many people, but only 38 people responded. The case study was a random selection of participants and not everyone was willing to participate in the interview. The target was to conduct the usability test with at least 20 people, however, only 7 individuals took part in the usability test and the interview.

3.6 Data analysis methods

This research followed Wilson's qualitative analysis methods, which included transcribing the audio records from the case study interviews into text, reading and generating categories, themes, and patterns to analyze users´ interactions and behavior within a PWA, interpreting the findings, and writing the report (3). Initially, notable observations during the interviews were noted, the recorded interviews were transcribed, and the qualitative data from the survey was quantified.

4 RESULTS AND ANALYSIS

This chapter presents the findings from the research on the impact of Progressive Web Applications (PWAs) on users´ engagement. The analysis is based on a mixed-methods approach, incorporating qualitative data from general surveys on PWAs, interviews, and usability tests conducted with users of the AliExpress PWA. The chapter is structured to first quantify the qualitative data, present the qualitative findings, and then visualize the data through charts for better understanding. It is worth noting that the number of responses obtained from the survey and the usability test is small because not everyone was willing to participate.

4.1 Users´ Survey Data and Feedback

A survey was conducted to gather data on users´ preferences, behavior, and satisfaction levels with PWAs. A total of 38 participants took the survey and the questions focused on many aspects such as ease of use, responsiveness, performance, personalization, offline access, adding PWA to a device´s home screen, and overall satisfaction of participants. Participants rated various features on a scale of 0(very unsatisfied) to 10 (Very satisfied). Ratings equal to or greater than 5 are considered positive comments and ratings below 5 are considered negative comments. The data summarized in Table 5, highlights the high ratings for performance, ease of use, personalization, and overall satisfaction of a majority of the participants.

TABLE 5. Participants´ comments on key features of PWA

Feature	**Frequency of positive comments** **(Ratings greater than or equal to 5)**	**Frequency of negative comments** **(Ratings less than 5)**
Responsiveness	28	8
Performance/Functionality	30	6
Ease of use	32	6
Personalization	31	5
Offline access	12	5
Adding PWA on the device´s home screen	25	4
Push notifications	20	4
User Interface	22	1

During the survey, participants were also asked to rate their overall level of satisfaction with PWAs on a scale of 0 (Very unsatisfied) to 10 (Very satisfied). Table 6 shows the rating of participants.

TABLE 6. Participants' overall satisfaction with PWAs

Satisfaction level (0 to 10)	**Frequency of comments**
Very satisfied (8 to 10)	26
Satisfied (6 to 7)	4
Neutral (5)	5
Unsatisfied (1 to 4)	3
Very Unsatisfied (0)	0

TABLE 7. Preference between PWA and Native mobile applications

Application	**Frequency of comments**
Progressive Web Application (PWA)	13
Native Mobile Application	13
No preference	8

During the survey, participants were asked to provide open feedback on what they liked and disliked about Progressive Web Applications (PWAs). Some of the participants gave the following feedback:

Positive Feedback:

- Push notifications and ease of navigation of PWAs were appreciated by one of the participants.
- Some of the participants indicated that they like PWAs because they load faster and are lightweight.
- A participant also noted that adding PWA to a home screen saves his time by eliminating the need to repeatedly type the application's URL.

However, participants also noted several drawbacks:

Negative Feedback:

- Some participants indicated that some of the push notifications they receive are irrelevant.
- A participant also indicated that certain features of PWAs are buried within menus, making them hard to find and use.
- According to a participant, PWAs do not always perform consistently across different browsers.
- Some of the participants disliked PWAs because of bugs, display errors, slowness, and occasional crashes.

- One of the participants also pointed out that some PWAs include too many features, which can be overwhelming and may not scale well across different devices.

Participants' reasons for their preference between PWA and Native mobile applications

- Some participants preferred PWAs over native mobile applications because PWAs can be directly accessed from the web without the need to be downloaded on the device. Additionally, the applications can be added to the home screen of their devices, thereby saving storage space.
- Other participants chose native mobile applications due to their more seamless and smoother user experience compared to PWAs. The participants mentioned that they encountered bugs and errors with PWAs, which failed to display content correctly, leading to a negative experience. Although they heard that PWAs have improved over the years, they have not used any PWA recently due to these past issues.

4.2 Case Study Analysis

The case study of AliExpress, a prominent e-commerce platform, demonstrated that PWAs are almost on the same scale as native mobile applications.

4.2.1 Usability test

Usability tests were conducted to observe how users interact with the AliExpress PWA and to also understand their preference between the PWA version and the native mobile application counterpart of the e-commerce platform in real time. During the usability tests, several noteworthy observations were made. Firstly, both users and non-users of AliExpress commercial applications could use the application effectively. All participants were able to update their profiles on the native application, but none of the participants could update their profiles on the PWA because of its layout.

4.2.2 Interviews After Usability Test

After conducting a usability test on both users and non-users of AliExpress commercial Applications, the interview revealed the following key points from the participants:
Participant 1 (Age 35-40, Student): A regular user of AliExpress, they noted that both the PWA and the native mobile application perform almost the same, but they preferred the native mobile application because of its layout and ease of navigation compared to the PWA.

Participant 2 (Age 18-24, Student): A first-time user of AliExpress, though familiar with other commercial applications like Jumia and Temu. They found the native application easier to use than the PWA because of the layout. They mentioned that the PWA's storage-free nature was good due to her phone's low storage capacity, but they preferred the native mobile application.

Participant 3 (Age 25-34, Courier Rider): They have used AliExpress multiple times and found the product details and reviews more straightforward on the native application. They said both applications work the same, and since they are not regular users of AliExpress, they preferred the PWA to save storage space on their devices.

Participant 4 (Age 18-24, Nursing Student): A first-time user of AliExpress, familiar with other commercial websites like Temu. After performing the tasks on both applications, they said there was not much difference except that products were better listed in the native mobile application. They preferred the PWA because it did not require any download.

Participant 5 (Age 40-45, Courier Rider): They have used AliExpress once before. After performing the same tasks on both applications, they said exploring different product categories was faster and smoother on the native application. They found the layout of the native mobile application more organized and preferred it over the PWA version.

Participant 6 (Age 25-34, Mechanical Engineering Student): A frequent user of AliExpress, they said both applications are easy to use, but the native application has a clearer and more user-friendly layout. They preferred the native mobile application because of its friendly layout.

Participant 7 (Age 35-40, Restaurant Worker): A regular user of AliExpress, found using the PWA directly from the browser more convenient because they did not want to download many applications on their devices. However, they said that the PWA's layout made it harder to browse and compare items.

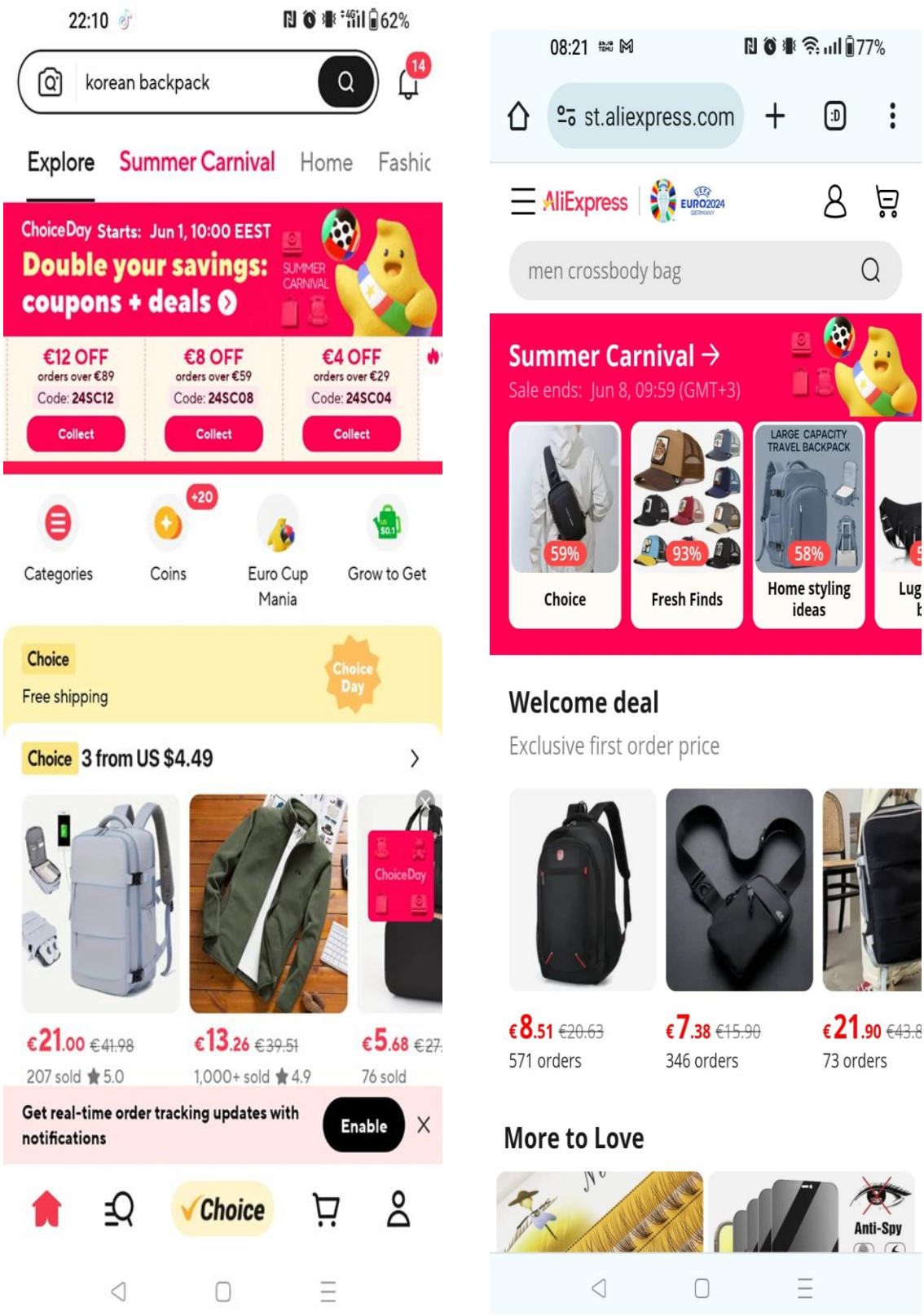

FIGURE 7. Home page view of Native Mobile Application on the left side and the PWA of AliExpress on the right

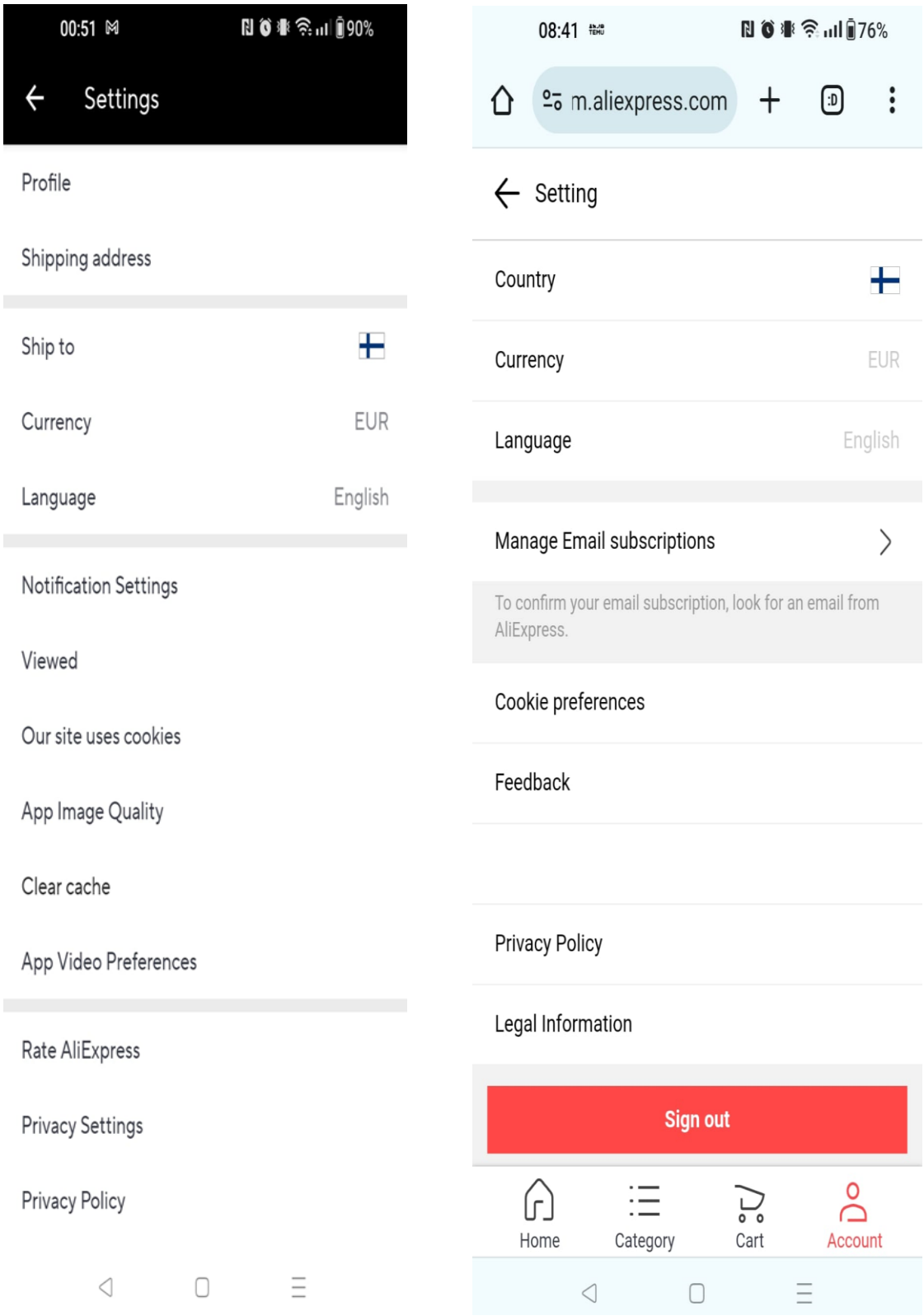

FIGURE 8. Settings for account updates for the Native mobile application and PWA of AliExpress

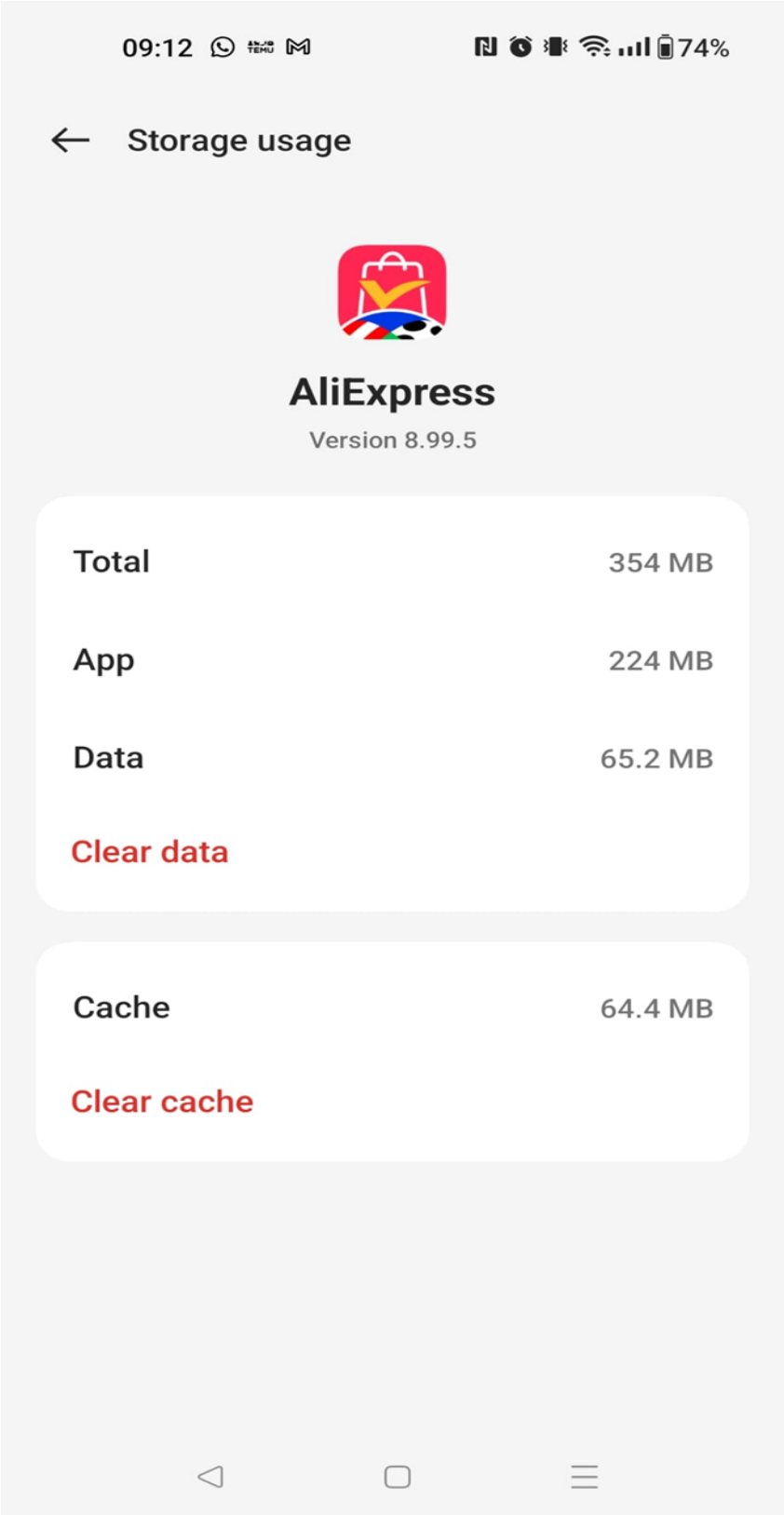
09:12
74%
Storage usage
AliExpress
Version 8.99.5
Total
354 MB
App
224 MB
Data
65.2 MB
Clear data
Cache
64.4 MB
Clear cache

FIGURE 9. Storage capacity of Native mobile application of AliExpress

No storage capacity for the PWA since it is accessed from the browsers.

4.3 Visualization of Qualitative Data

The following bar charts are used to give a comprehensive understanding of the qualitative data obtained from the survey on some key features of PWAs.

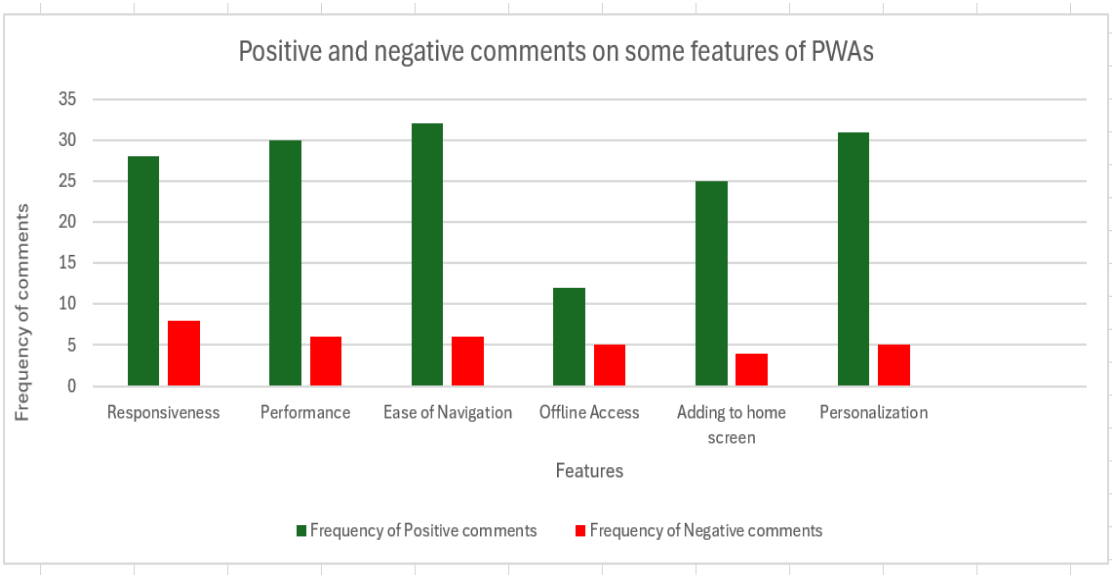

FIGURE 10. Frequency of positive and negative comments on PWAs features.

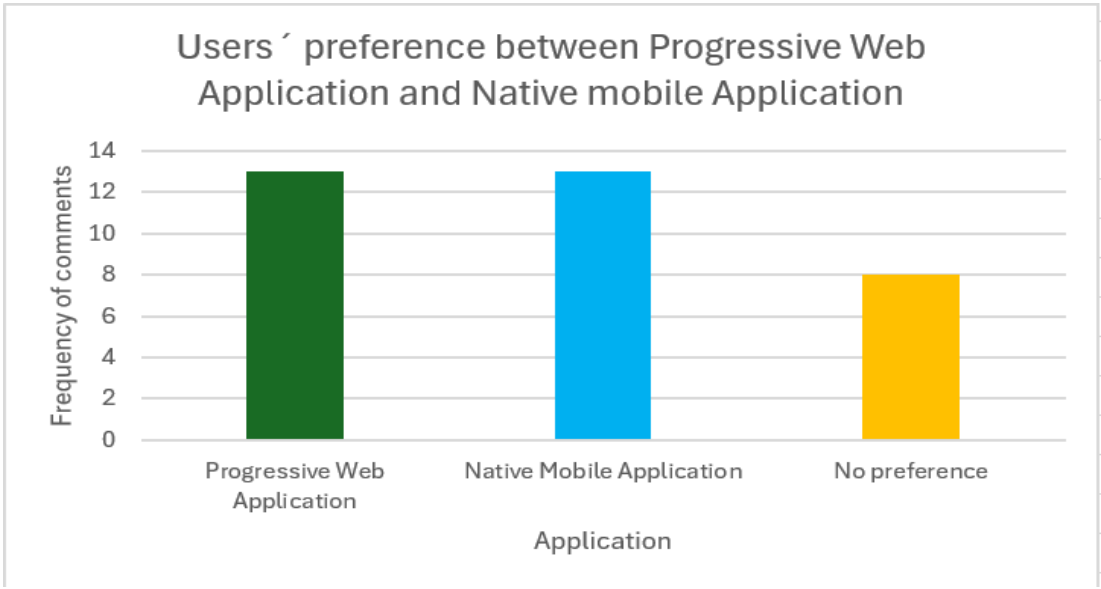

FIGURE 11. Users' preference between PWA and Native mobile application

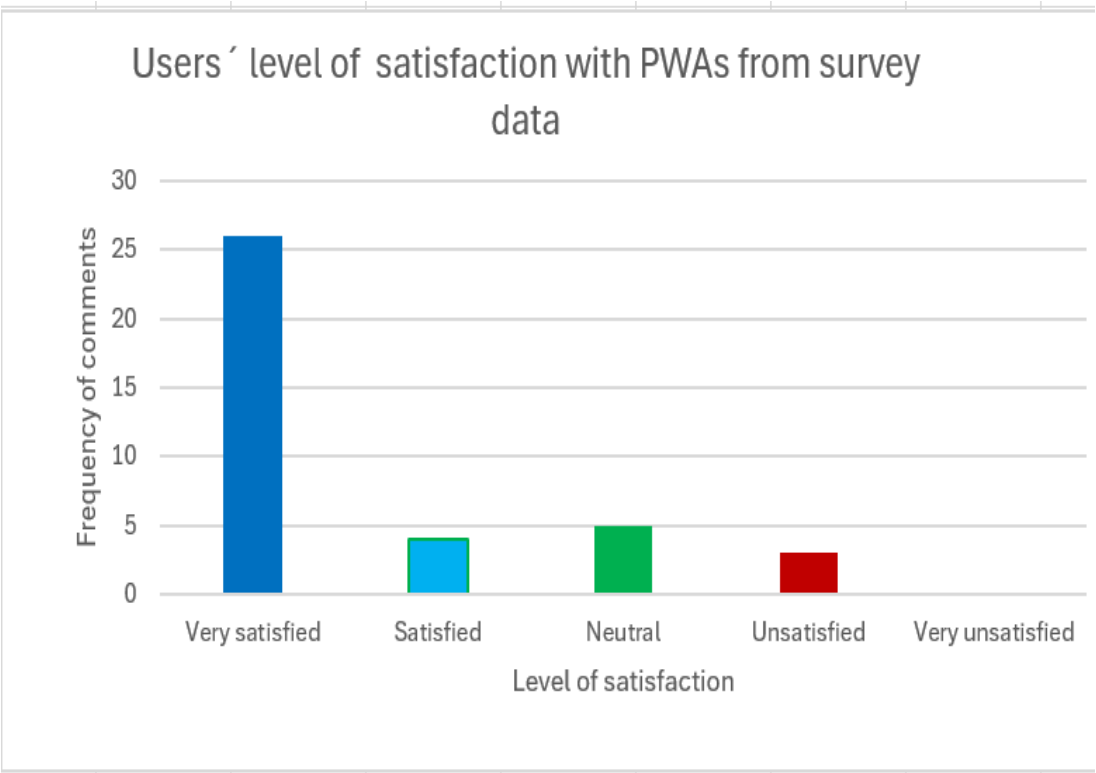

FIGURE 12. Users´ satisfaction levels

5 DISCUSSIONS

5.1 Key Findings

Findings show that PWAs have users´ engagement comparable to native mobile applications because they offer an app-like experience without requiring any installation which many participants during the survey considered as an added advantage.

The data analysis from the survey revealed that features like offline access, push notifications, and responsiveness significantly enhance user engagement. PWAs' ability to provide a smooth users´ experience across various devices is also a major factor in their success.

5.1.1 Higher User Satisfaction

Users' reports from the survey indicated higher satisfaction levels with PWAs due to their app-like experience, responsiveness, and reliability. The ability of PWAs to function offline and deliver consistent performance across different devices enhances overall satisfaction.

5.1.2 Enhanced User Engagement

The research also discovered that PWAs significantly improve user engagement based on participants´ ratings on features such as responsiveness of PWA, personalization, and functionality. Features like offline access and push notifications play an important role in keeping users engaged.

5.1.3 Installation and Layout of AliExpress

Findings from the usability test and the interview found that most users are comfortable with both PWA and the native mobile application of the e-commerce platform, a majority of the end-users prefer to use the native application of AliExpress because of its straightforward and easy-to-navigate layout while others believe that they can still get the same satisfaction by using the PWA of the platform without downloading the application in their devices.

5.2 Theoretical Implications

Based on the ratings obtained from the survey reports, PWAs are useful and easy to use. This finding therefore supports the Technology Acceptance Model (TAM), which says that usefulness and ease of use are critical for people to adopt a new technology.

The survey showed that many people find PWAs easy to use and would recommend them to friends. Tests on AliExpress PWA also found that some people prefer PWAs because they do not need to be downloaded and installed. This supports UTAUT's idea that how well technology works, how easy it is to use, and its social influence, all affect if people would use it. PWAs do well in these areas, which helps keep people engaged with them.

5.3 Practical Implications

Based on the research, developers can focus on the layout of PWAs by creating easy-to-navigate PWA that feel like native applications. This is important for keeping users fully engaged and happy.

By using data and users´ preferences, businesses can offer personalized experiences that meet individuals` needs and interests, thereby increasing engagement and satisfaction.

Businesses can use push notifications to keep users informed and engaged. These notifications should be limited, timely, relevant, and personalized to add value to the users´ experience.

5.4 Recommendations

5.4.1 Recommendations for Developers

Enhancing User Experience: Considering the feedback on the layout of PWAs, developers should focus on creating an easy-to-navigate PWAs layout to increase users´ engagement with PWAs.

Improving offline capabilities: Survey data shows the lowest rating from participants. Developers should improve in this area so that users of PWA can use the application in poor or no internet connection environments.

Optimizing Performance: Developers should focus on minimizing load times and ensuring smooth transitions through efficient resource management and caching strategies.

5.4.2 Recommendations for Businesses

Based on the feedback from the survey and the participant´s reactions during the usability tests, businesses that have adopted PWAs should consider the following recommendations:

Push notifications, businesses should send notifications to users with important updates, and notifications to keep them engaged. It is important for businesses to avoid sending too many irrelevant notifications, as this may cause some users to feel overwhelmed and discontinue using PWAs.

Also, increasing users´ retention strategies should be considered by businesses. To enhance users´ retention, businesses should offer personalized content and loyalty programs that make users want to re-engage with PWAs. Monitoring how users behave is important for making this idea work well.

Lastly, personalization and customization should be used whereby businesses use the information about the users to understand their preferences and offer them personalized experiences. This increases users´ satisfaction and makes them engage more.

5.4.3 Recommendations for Companies

Companies should identify specific users´ needs and ensure PWA features meet these needs. Investing in thorough user research and testing is very important for successful implementation.

Proper training and development should be provided. Providing training for development teams on PWA technologies and best practices ensures a smooth transition and effective implementation.

Companies should set up a framework for tracking and analyzing engagement metrics. This helps in understanding user behavior and continuously improving the application.

5.5 Limitations of study

The limitation of this study is its small sample size, which may not accurately represent the broader population of PWA users. Future research with larger sample sizes could provide more generalizable results.

The study focused on AliExpress, and a general survey on PWAs to get an overview of users' perceptions of PWAs. The findings may not apply to all industries or types of PWAs, suggesting a need for further research in various contexts.

5.6 Recommendations for future research

Future research should incorporate longitudinal studies to understand the long-term impact of PWAs on user engagement. Researching users´ behavior over extended periods can reveal trends and patterns that short-term studies might not discover.

Investigating the impact of PWAs across different industries and cultural contexts can provide a detailed understanding of their effectiveness. This includes exploring PWAs in other sectors like education and health

Though this research covered different countries and age groups; further and in-depth research should consider how different demographical factors can influence PWA adoption and engagement. Understanding these variations can help in designing more effective PWAs.

6 CONCLUSIONS

The study from the general survey found that the majority of users are satisfied with PWAs. Progressive Web Applications significantly enhance users´ engagement through features like push notifications, ease of use, and responsiveness. These features contribute to higher engagement and retention rates. Despite this finding, usability tests with AliExpress PWA and the native mobile application showed that the layout of PWA was not easy to navigate compared to the native mobile application. However, the layout limitation of AliExpress does not necessarily apply to other PWAs.

In summary, PWAs represent a significant advancement in web technology, offering a blend of the best features of web and mobile applications. Their ability to provide a smooth and engaging users´ experience that is comparable with the native application counterpart positions them as a powerful tool for enhancing users´ engagement.

Through this research, key features of PWAs that enhance users´ engagement and the core technologies of PWAs were understood. The research has contributed significantly to my professional growth in several ways. Firstly, the process of gathering and quantifying qualitative data has increased my skills in both qualitative and quantitative research methodologies. Besides this, analyzing different data sets and presenting the research findings through charts have improved my analytical abilities and technical communication skills which are all important in presenting complex information in the field of engineering and technology.

Another area in which the research has contributed to my professional growth is project management and planning. Managing research from the beginning to the end requires proper and effective planning and management, which is one of the beneficial skills acquired during the research.

Additionally, identifying the key features of PWAs that enhance users´ engagement, and the areas with limitations that need innovation has increased my problem-solving skills. This is an important skill in the field of technology and engineering because technology and its products become useless if end-users cannot fully utilize them, probably because their problems are not identified and solved or innovated.

It is of utmost importance to mention some of the limitations of the research on Progressive Web Applications on users´ engagement. One of the main limitations of this research is the sample size, a limited number of participants took part in the survey, and the usability test. The limited number of participants does not give a comprehensive view of users´ engagement and might not be generalized. Also, different users´ behavior and preferences made it challenging to draw general conclusions aboutusers´ engagement.

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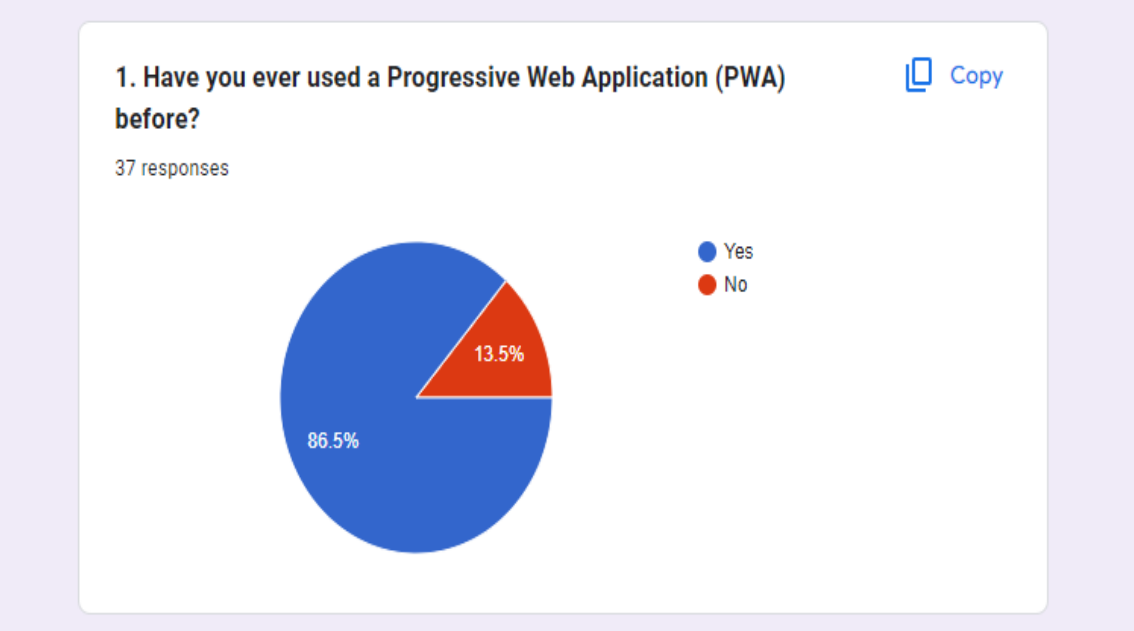
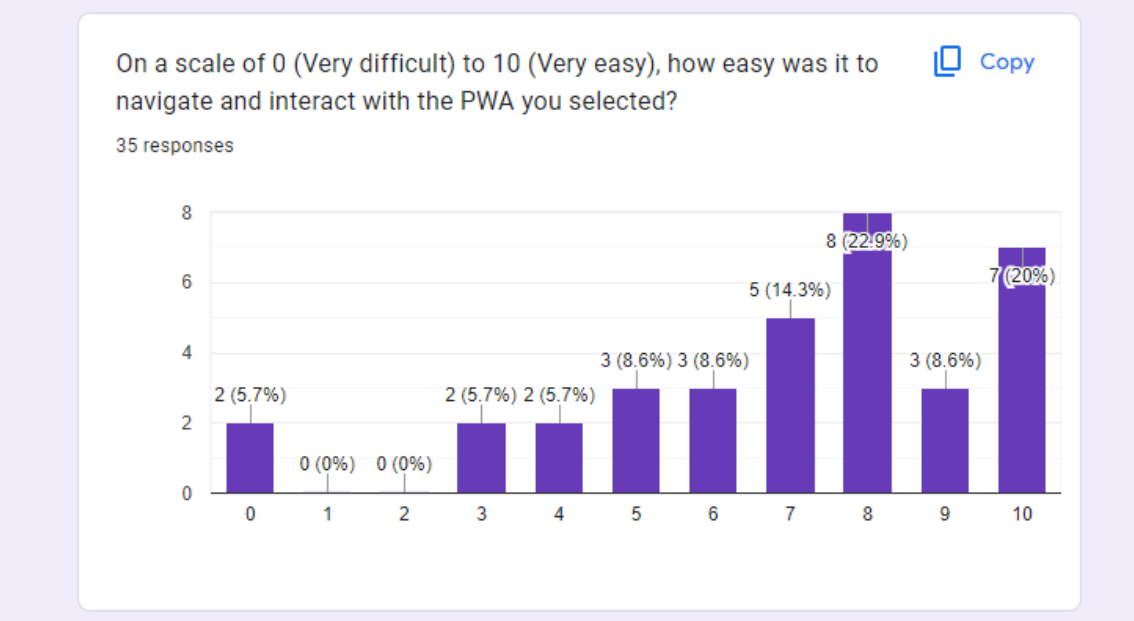
8 APPENDICES





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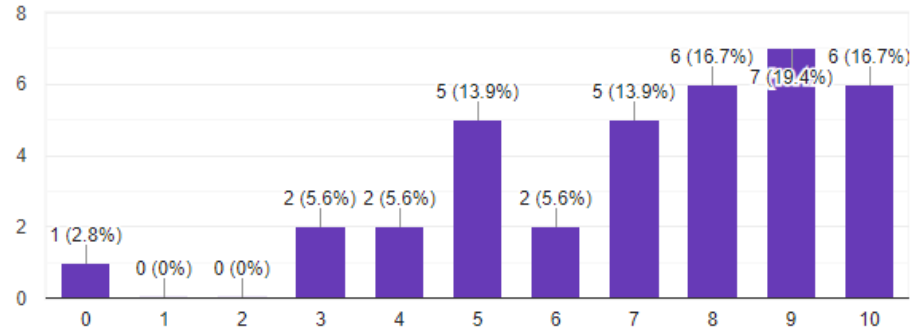
To what extent did the PWA provide personalized experiences when compared to your preferences? Please rate from 0 (not personalized at all) to 10 (highly personalized).

36 responses



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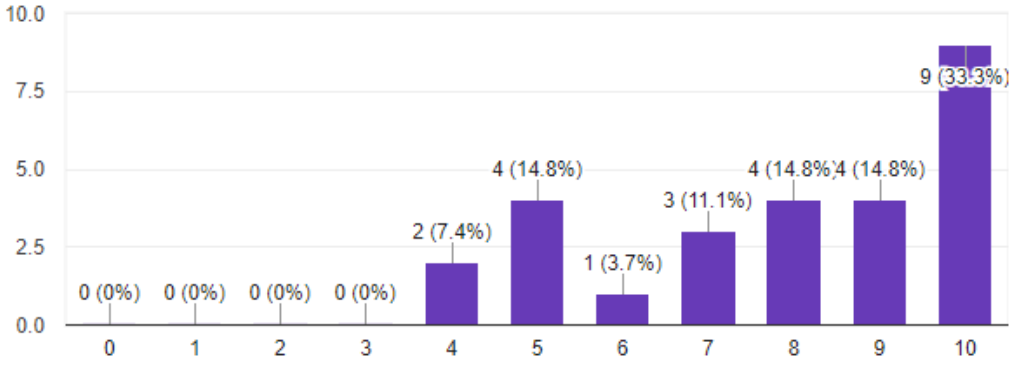
11 c) How would you rate the ease of adding device`s home screen or installing the PWA on your device?
Please rate on the scale of 0 (Very difficult) to 10 (Very easy)

27 responses



11 e) Do you find the PWA's interface consistent and user-friendly across different devices and screen sizes?

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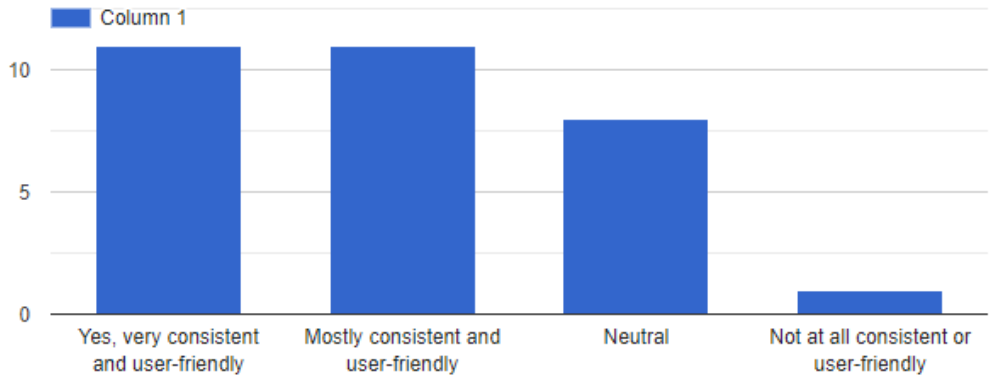

12 c) Have push notifications influenced your engagement with the PWA (e.g., prompting you to revisit the app or take specific actions)?

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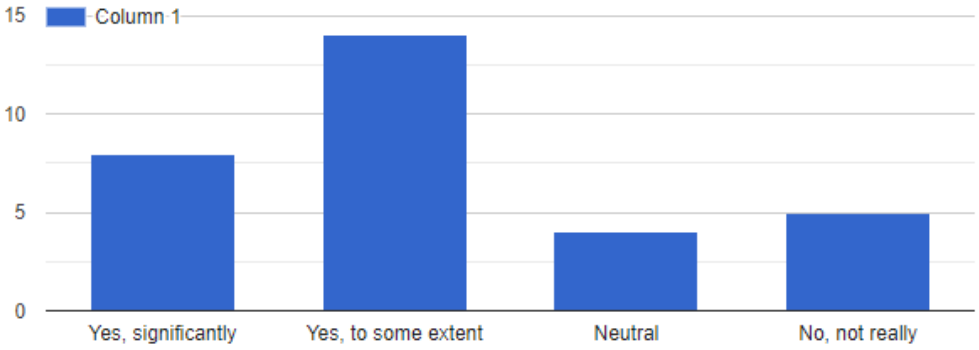

12 e) Would you recommend this PWA to others based on its installation process and engagement features?

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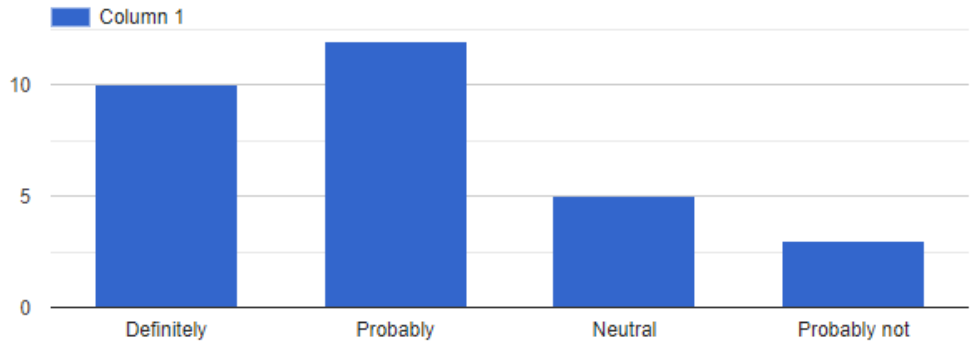

14. Overall Satisfaction

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On a scale of 0 to 10, how satisfied were you overall with your experience using the PWA, considering all its features and functionalities?

33 responses