applied sciences

MDPI

Article

Intelligence and Usability Empowerment of Smartphone Adaptive Features

Ahmed Mohammed Alghamdi [1,*], Hafsa Riasat [2], Muhammad Waseem Iqbal [2], Muhammad Usman Ashraf [3], Abdullah Alshahrani [4] and Adel Alshamrani [5]

[1] Department of Software Engineering, College of Computer Science and Engineering, University of Jeddah, Jeddah 21493, Saudi Arabia
[2] Department of Software Engineering, Superior University, Lahore 54000, Pakistan
[3] Department of Computer Science, GC Women University, Sialkot 53310, Pakistan
[4] Department of Computer Science and Artificial Intelligence, College of Computer Science and Engineering, University of Jeddah, Jeddah 21493, Saudi Arabia
[5] Department of Cybersecurity, College of Computer Science and Engineering, University of Jeddah, Jeddah 21493, Saudi Arabia
* Correspondence: amalghamdi@uj.edu.sa

Abstract: In adaptivity, the interface of the device automatically adjusts and assists the user. The adaptive user interfaces can adapt their activities by monitoring user status, the state of the system, and the current situation according to the adaptation strategy. Usually, the intensity of adaptation is measured in effectiveness, efficiency, and satisfaction to analyze the smartphone's adaptive features. The adaptive features of light-emitting diode (LED) notifications, voice commands, face recognition, screen rotation, kid mode, drive mode, night mode, Swift Keyboard, s-health, gesture recognition, and fingerprint are selected for both iOS and Android platforms. Task completion within a specific time frame is used to measure effectiveness and efficiency, while satisfaction is calculated using the after-scenario questionnaire (ASQ). A total of 550 users are involved in the experimentation. The usability evaluation is measured for smartphone features. The effectiveness of adaptive features contains higher adaptivity in face recognition (87%) and voice command (85%). Furthermore, the satisfaction level is greater for adaptive features than non-adaptive features. This study indicates that adaptive features can only be used after a thorough examination of the user's context. Furthermore, the usability evaluation shows that there is a dire need for adaptive smartphone features to provide ease and satisfaction to the user.

Keywords: adaptiveness; adaptivity; usability; smartphone; UI/UX

Citation: Alghamdi, A.M.; Riasat, H.; Iqbal, M.W.; Ashraf, M.U.; Alshahrani, A.; Alshamrani, A. Intelligence and Usability Empowerment of Smartphone Adaptive Features. *Appl. Sci.* **2022**, *12*, 12245. https://doi.org/10.3390/app122312245

Academic Editor: Miguel Ángel Redondo Duque

Received: 30 October 2022
Accepted: 28 November 2022
Published: 30 November 2022

1. Introduction

The most widespread and greatly used devices in the world are smartphones. Everyone has a smartphone and they keep them to complete their daily tasks according to their needs. In 2021, there are expected to be nearly 6.3 billion smartphone consumers in the world [1]. The mobile phone was designed only for calling intentions [2]. Currently, smartphones are becoming more intelligent in understanding user constraints, and cell phone operating systems offer services that help users address obstacles to the use of information and communication technology in their context [3]. Due to its peculiar aspects and demands, smartphone usage is a crucial area in prevalent computing [4]. Smartphones are also known as a subsequent generation, multifunctional cell phones that enable the handling of data and improved wireless connectivity [5]. The mobile is completely incorporated into our lives in the modern world [6]. The need to bring several items, including a phone, camera, speakers, Wi-Fi adapter, and Global Positioning System (GPS), etc., is removed by one smartphone [7]. Furthermore, a 2015 survey found that 46 percent of Americans indicated that without their smartphone they could not survive at all [8].

Statistics indicate that one out of every three people owns a smartphone [9]. The variant versions of smartphone applications (Apps) are expanding very quickly. Over time, with the development of mobile communication devices, smartphones, and tablets, the digital revolution turned into a system called the "smart revolution" [10].

In today's world, smart devices have made huge modifications and we, mortal beings, are becoming in need of them as well, since smart devices can perform our regular activities [11]. A survey shows 92.8% of individuals utilize a smartphone to pile their reserved material. These mobile devices may be at the core of smart atmospheres [12]. A cell phone is the most portable sensing device an individual carries with them [13].

1.1. Smartphone Operating Systems

Android (Google) and iPhone (Apple) are the most popular operating systems (OS) and have various features for several apps. Although iOS is the marathoner with a 17.7% market share, these two smartphone operating systems share the market. Technological developments are not only ritual gadgets, but they show an increasingly significant role in the everyday lives of people [14]. A smartphone operating system produced by Apple was incorporated for mobile devices. This OS was first designed for the iPhone and later expanded to other Apple products [15]. Overall, the highest numbers of mobile technology use are among young people [16].

Android is the utmost common cell phone OS in the domain, and the Android system is used by several smartphone users [17]. User experience has been the primary concern of the ones listed, because the consumers of an application and their decision eventually determine its outcome [18].

1.2. Role of User Interfaces

User experience (UX) has evolved into a crucial component that should be considered while designing products and services. Employers are looking for exceptional individuals who can contribute to interdisciplinary and multicultural teams while being user-centered, imaginative, and practical. The demand for talent has spurred the growth of UX education. However, the typical master's degree in academia, which emphasizes research, is no longer able to satisfy the educational requirements for multidisciplinary practical talents in UX. The primary focus of human–computer interaction (HCI) engineering education has been on viability. HCD necessitates cooperation with and a deeper comprehension of the methodology of social scientists in the domains of cognitive psychology, sociology, and cultural anthropology. After becoming experts in the social sciences, our challenge and chance are to become equally knowledgeable about human values as we are about technological and analytical problems. This enables us to create goods, services, and culturally meaningful experiences that people value as individuals and as a group. We take the approach of researching and monitoring humans to understand their goals and latent needs and to build adequately gratifying solutions that make a difference, rather than relying solely on new technological advancements that we are seeking to exploit [19]. User experience (UX) challenges of difficulty and consistency exist with the user interfaces (UIs) of many apps. The physical shortcomings of smartphones not only impair the screen size and method of interaction but also lead to many mobile application usability problems. For digital devices, accessibility is among the most significant considerations. ISO 9241-11 describes usability as the degree to which individual users can use a device, feature, or service to achieve specified purposes in a given context of usage with quality, efficiency, and satisfaction [20]. The other concept of reliability can be found in ISO/IEC 25010, which replaced ISO/IEC 9126 in 2001 [1]. Three types of problems are posed:

The technical usage of the network, restricted battery life, and the screen size of mobiles.

Environmental usability talks about intellectual capabilities, psychological limitations, agility, noise, temperature, and user conditions.

The question of user personality, privacy, approval, comfort, and acceptance are specified in social usability.

Usability refers to how effective and efficient customer success is in performing the job with the provided interface and fewer mistakes. As a contextual heterogeneity approach, self-adaptive UIs have been marketed because of the potential to adapt to the framework of use in runtime automatically [21]. The degree of user-friendliness is called usability, and there are several usability reports available on diverse innovations in various contexts [22].

1.3. Adaptive User Interfaces

A user-centered system design survey component. Hooper sensitively discusses the similarities between architectural and interface design and includes that the effectiveness of design artifacts depends on user input on their intended uses. Although some exploratory evaluative studies of systems are made possible by rapid system prototyping, there are still challenges in choosing system components for formative assessment and developing evaluating criteria [23]. AUI is defined as a system that analyzes user status to adjust the different sizes and actions to the user's desired goals. Literally, in AUIs, the user-based interface needs to be flexible and adaptable instead of the user-based interface being adaptive. Currently, some vendors are trying to cater to these adaptivity issues in the favor of users. No doubt, it is not an easy task to handle the user's context from a different perspective, because every user has their point of view [5]. The consistency and usability of smartphone apps are considered important features of quality. Usability is a consistency factor that measures by what means simple and concise user interfaces can be used [24].

1.4. Role of HCI

Human–computer interaction (HCI) is the analysis that is responsible for interactions between human beings and computers, particularly in consumer reaction time. The interactive design addresses the context needed by offering users learning, protection, usage, performance, efficiency, and satisfaction. Essentially, HCI deals with the creation, assessment, and deployment of interactive computer systems. Interactive programming is synonymous with emotions, gestures, and phrases [25].

1.5. User-Centered Design Approach

In the wider sense, the user-centered design (UCD) approach is used to design and implement APIs. It provides us with adaptation guidance that is acceptable for users and different contexts. Context-conscious systems can adjust their processes to the actual situation without the need for explicit operators to interfere and are thus designed with environmental considerations to improve usability and performance [26]. The user context in terms of mobile users can shift for many applications [27].

1.6. Adaptive Features in Smartphones

There are a lot of adaptive features in our smartphones that we can keep on that are used on a daily basis. Alerts are becoming the most critical aspect of engaging consumers without thinking about their everyday life. Constant interruptions can induce inattention and hyperactivity in digitally linked communities. On the other hand, some people believe that alerts are important and do not affect their everyday lives [5]. Push alerts are theoretically exciting from a political viewpoint as they not only inspire people to participate in reporting but also help people understand what is going on in the world [28].

Smart alerts have proven that they are capable of anticipating consumer habits for delaying phone call notifications in various situations. The in-context system has learned how to mute phone call notifications, taking into account different degrees of user suspension [29]. The only clear result among the participants was that none of them would leave alerts disabled entirely. Notifications can impact an individual, but they are crucial: users cannot survive with or without them. This problem has lately come to the fore, as the amount of interrupting push alerts hitting mobile users has risen dramatically. Smart devices use alerts to remind users about activities, such as phone calls [30].

Furthermore, the voice instructions are executed automatically with no need to find and locate objects on the device. The most popular apps are Apple's Siri and Google Now, which help users to execute tasks by delivering voice instructions. Voice interfaces are becoming more prominent and are now the main input form for a variety of applications [31]. The screen rotation feature, in which concerns of usability are defined for automatic screen rotation, where users can surf/browse by portrait or landscape orders, even though the effect of inappropriate orientation when users transform their location is also analyzed. Parent guard systems are in serious necessity of this. In addition, because guardians and children frequently use identical electronic devices, children may be capable to inflict secrecy or monetary harm to their guardians, such as leaking secretive images or account information accidentally or buying products without elders' permission. In summary, both parent guard and parent asset security systems are important to shield both youngsters and parents, as they use identical equipment. The troubling overuse of electronic devices, especially smartphones, harms the lives of young Americans [32].

Using a mobile while driving is known to be a very risky practice that may endanger the lives of people in cars, travelers, and pedestrians. Cell phone use and then driving has been identified as the biggest threats to road safety globally. Based on conceptual driving research undertaken in the U.S., the risk of a collision is predicted to increase by 73% for drivers engaging in cell phone visual–manual tasks [28]. Despite the ability of these technologies to avoid distracted driving-related collisions, research has yet to investigate these new solutions [33]. Medical research refers to disrupted sleep as the root cause of health-related problems impacting Western society. Things such as sleep, sleep-related conditions, and sleep-enhancing solutions often draw greater interest from newspapers, magazines, and public broadcasters. Some systems require manual mode switching action [34].

Moreover, the adverse effects of night lights on human beings and the environment are quite well understood by the broad-spectrum community. Any implementations have night mode and day mode in the program that launches the graphical user interface (GUI). In certain implementations, the interface displays icons for the startup program in a different format in night mode than in day mode [3]. Swift Keyboard in the 2000s was popular for cell phones in order to have a QWERTY keyboard, even though some of the phones had touchscreens that allowed the simulated/virtual keyboard to take its place [11]. Text entry is central to most computer devices, from desktops to laptops to game consoles and smartphones. Typing blunders are popular when using virtual keyboards on smartphones. To stop these and speed up typing, most keyboards now feature self-correct and customized tips. The QWERTY keyboard on a small screen is very small, with any click on a virtual keyboard. More frequently than not, when typing on these keyboards, there will be typos that arise due to a minor misplacement of a finger from the intended key [35].

Face detection can be achieved using neural learning methods with features taking out and training modules. The photos of friends and family are kept in the mobile user database [33]. Smartphone functionality and use have improved dramatically over the last small number of years. The growing volume of confidential data on smartphones makes them a common target for stealing [34]. Among many of the latest acoustic signal-based recognition applications, human hand gesture recognition has become a hot subject of research and gained further interest because it can have many marvelous applications such as game management, computer unlocking, identification verification, knowledge input, etc. [36].

Additionally, with a touchscreen, smartphones deliver a wide variety of features that millions of people use. Although maximum functions are available within a variety of keys, others are used so often that shortcuts have been implemented. Smart health (s-health) can be seen as a context-aware extension of mobile health, incorporating wireless connectivity technology to provide healthcare consumers with creative apparatuses and solutions that can revolutionize service delivery [37]. Biometrics, particularly those using fingerprints or the face, are already standard on many smartphones, and many users use them to unlock

screens. Among these authentication mechanisms, biometrics such as fingerprints are rapidly being regarded as viable alternatives to passwords [38].

The objective of this study is to evaluate the usability of adaptive and non-adaptive features in smartphones. The contribution may help to increase the usability of different features of smartphones according to user context. The article is divided into different sections, in which Section 2 elucidates the background and literature review. Section 3 clarifies the research methodology, whereas Section 4 states the results and discussion. The last Section (5) elaborates on the conclusion and future work.

2. Literature Review

Technology plays an important role in everyone's life routine [14]. Smartphones are a lot in use these days, but youngsters are more addicted users than their elders or old people. Children use the phone for social media and games most of the time, but elders only use the phone for normal communication and to stay updated [4].

Smartphones are often known as "multifunctional cell phones of the next generation", facilitating both data collection and better wireless connectivity. Considering the wide variety of intelligent uses so far, sensors have been involved. As technology expands, such as a smartphone blaze, some issues cannot be invisible. The supremely troublesome thing is seeking the answer to some prominent issues such as storage, phone hanging, touch, reliability, learnability, and usability. Smart systems have the efficacy of a word for face detection, and a Bluetooth kit makes it more accurate for a client. The approach also moves toward the question of how smart devices can be used for water consistency if it gets plunged into the sea [11].

The study states that the ISO 9241-11 term is used as a standard for mobile app usability. Usability is always related to the product, apart from Bevan's definitions and IEEE glossary, which concentrate on the user. In sum, 75 attributes have been differentiated in the 790 papers, indexed in the Scopus archive. Quality (70%) and happiness are the most common (66%), as quality and efficiency (58%) come from the above-defined meaning. After that are the less regular learnability (45%), memorability (23%), cognitive load (19%), and mistakes (17%). Simplicity represents 13%, and the last two are concerned with simplicity of use (9%). Four of the remaining characteristics happen in moments or less [18].

Furthermore, the study claims that interfaces should be built to be sufficiently agile to satisfy the diverse elderly criteria when communicating with smartphones. The normal user fallacy has been negated, development for all is a fact that needs to be carried out, and tasks are in view [6]. Research presents the outcomes of an overview of App Store's 106 behavioral health app ratings, as well as those from Google Play. The reseaerchers extracted and evaluated independent feedback to find usability concerns. Software usability problems are graded into six categories, which are glitches, bad design of the user interface, lack of data, battery, issues related to memory use, lack of direction and clarification, and the problem of internet access. The findings could guide app designers on what way to design applications geared specifically to mental health to maximize usability [33], such as the use of context-aware rules to construct domain-specific context and different context-aware structures for end-users to support themselves perceptively in their contextual day-to-day processes. This needs high-precision and high-precision sophisticated data analysis techniques, and smart context-based techniques for decision making. Compared with traditional approaches, strategies based on machine learning offer more powerful and effective results for the analytics of mobile data and related context-aware learning law [36].

HCI's basic goal is to make the structures more available and valuable and improve usability in line with the experiences of consumers. In comparison, analysis in this field appears to highlight the fact that there is an adverse correlation between old age and the consumers around information communication technology (ICT). Many elderly people's active lives, according to Nielsen, are driven by industrialized countries, and if they are, they generally retire, have a lively life, and also have a dynamic life. Additionally, they demonstrate a strong curiosity in modern developments such as cell phone appliances.

The same study indicates that 18% of older people are elderly. Smartphones are used by citizens, and there was a six percent rise in the acquisitionof these instruments by the elderly between 2010 and 2011 [14]. The study stated that the adaptive function of LED alerts contributes primarily to better usability, at nearly 88% performance and 89% efficiency [5]. Natalie Jomini Stroud et al. researched push notifications and found that the research makes a variety of contributions despite these shortcomings. By looking at push alerts, the report expands analysis on the impact of news exposure [2].

Likewise, the study creates a new calculation of interrupted ability and adaptive scheduling of alerts for redesigned technical components. The firm deploys the machine review to the actual product stack of Yahoo! development and the assessment of Japan's Android with 382,518 users for confirmed multiple important findings over 28 days. There was a maximum rise of 60.7 percent in the click rates of the consumers, 10 times more attainment compared with the previous method. Mobile alerts make it easy for apps to notify users of arriving notifications messages, new machine activities, and prompts but without the specific prerequisite of a relationship. Users receive upwards of 60 updates daily, all of which are deemed unimportant by the consignee [39].

The study defines message management system analysts to consider the peculiar notification habits of consumers. There must be future work concentrated on designing user-driven applications for message control [28,37].

Additionally, the article shows the nature and characteristics of an application for smart home automation. It is based on Bluetooth, and thus should be versatile in terms of cost. It has a specific function for the context of smart voice, which would decode user sentences into acceptable commands. As a safety medium, security details are required, thus the usage of the program is prohibited by illegal use [37].

Normally, there are different ways to operate a phone, especially if when talking about screen touch patterns; there is a difference in the usage pattern of a child and an adult/parent. An adopted approach is selected to detect that the kid uses a mobile without extra consideration from users. The pilot study of 17 trained support vector machine (SVM) and radiofrequency (RF) models shows that children and 14 adults with a single swipe will reach an equivalent error degree of 16 percent. With a sophisticated degree for teenagers aged 3 to 5 years old, precision can be obtained. They also find that at eight, the efficiency can be significantly improved by successive swipes [29].

Furthermore, the research discusses two means to improve the driving mode of the smartphone, the first is a mode where arriving SMS/calling is received. If the user is driving, alerts are blocked. The analysis reveals the precision of properly identifying the smartphones of drivers to make driving mode 92.5 percent. Additionally, they suggest the need for an automatic segregated warning mechanism through the autonomous selection of separate priority contact classes and assigning various means of warning while driving [37].

Another proposed analysis uses tree-based prediction data to forecast structures for predicting the key that a consumer would like to touch when punching in on a handheld device's console. Notable changes have been observed in the job tests in terms of the precision and speed of typing for around 3 weeks. In reality, good reviews from customers brings us to the fact that a very possible NexKey is a solution to the latest issues with mobile typing, as it the key roadblocks encountered while typing appear to be addressed [32].

Furthermore, the paper suggested a method for navigating blind individuals generously in the world by eluding barriers and even to arrange for a way to discover the person in front of them. The highlight of the suggested scheme is an intellectual and compact implement that is less costly, with self-contained navigation and facial recognition technologies. For both, the framework applies to outdoor and indoor conditions. The study of the results of the system implemented indicates that 75 percent of the system was executed, and visionless people learn that this device thoroughly assists and offers a 90% exact outcome for facial identification and 95% identification of barriers [33].

The usefulness of the authors' BehavDT approach for constructing user-centric context-aware prediction models has been demonstrated. Although we use the example of a phone call to explain the BehavDT paradigm, it may also be used in other user-centric application domains where the surrounding contexts influence the user's different behavioral actions [38].

3. Methodology

In this article, usability experimentation is conducted for smartphone features. The 11 adaptive features of smartphones are selected from Android and Apple OS. The usability evaluation is performed by the users while using different adaptive features of smartphones.

Nominated Adaptive Features

Smartphones and their apps are heavily in use these days. Every person has a cell phone and they are consuming all the rich features of their phones. There are a variety of apps that hold adaptive features. Adaptive features are crucial concerning the user context as they enhance usability in the sense that it helps in the completion of a chore, reduces screen disorder, inadequate interaction procedure, and so on. A huge number of apps are available on the Google Play store or the Apple App Store. According to the scenario, almost 67 apps were reviewed, which are available free of cost. The available apps usually belong to 7 diverse categories. These categories are (1) communication, (2) entertainment, (3) social networking, (4) news and information, (5) utility, (6) service provider, and (7) browsing.

Several apps are nominated which are frequently used by the users because of their free-of-cost availability and approachability. The commonly used 11 features selected are LED notifications, voice commands, face recognition, fingerprint, screen rotation, drive mode, night mode, Swift Keyboard, s-health, gesture recognition, and kid mode. Table 1 below shows the prons and cons of the selected features.

Table 1. Pros and Cons of selected features.

Features	Apps	Pros	Cons
LED notifications	• Flashlight • Notify buddy • Flash alert	• Do not miss important notifications • Lets you stay updated	• Impact battery timing • Distraction
Voice commands	• Google Assistance • Amazon Alexa • Siri	• Personal assistant • No need to type	• Understanding issues • Listening issues
Face recognition	• Face lock • Lux • App lock	• Improve security • High accuracy • Automated	• Technology imperfection • Data privacy • Reliability
Screen rotation	• Ultimate rotation control • Auto-rotate control-pro	• Fine-tune visual orientation	• Inappropriate moment • Distraction
Kid mode	• Kids place • Kids zone • Parental control	• Observe kids activities • Secure private data (account info)	• Limit the features • Examine events
Drive mode	• Drive mode • Drive smart	• Safety • Avoid distraction	• Miss important alerts • Urgent calls or SMS

Table 1. *Cont.*

Features	Apps	Pros	Cons
Night mode	• Dark mode • Night screen	• Low battery ditch • Visual ease	• Affect readability
Swift Keyboard	• Microsoft Swift Keyboard • Ginger keyboard	• Flow typing • Support multiple lan guages and keyboards	• Learning curves • Lengthy messages create inconvenience
S-health	• Samsung health • Fooducate	• Lets you stay healthy • Monitor sleep, food, sugar, etc.	N/A
Gesture recognition	• Gesture lock screen • Gestify gesture control • Navigation gesture	• Powerful interaction • Enjoy ability	• Recognition error • Memorability
Fingerprint	• App lock • Fingerprint locker • Fingerprint pattern app lock	• Security • Ease of use • Cost-effective	• System failure • Exclusion

4. Sampling and Experimentations

To experiment with the selected features, 938 people were selected to use different features, and then contestants were elected who were all almost mobile literate and had at least one year of smartphone usage experience. During sorting, 388 contestants were rejected because of their low visibility and inexperience. Finally, 550 contestants were selected for experimentation with an equal gender ratio and were further divided into 11 clusters. Each cluster contained 50 participants for usability evaluation of adaptive features for mobile devices. The participants were young students as well as office workers between the ages of 18 to 36 years old. The kid participants were excluded from experimentation and contained the ages of 4 to 9 years old. We demonstrated the significance and measures of the assigned tasks briefly. Experiments were held in a controlled environment in labs for adults, while for kids they were performed in different schools for a specified given age [37].

The contestants used Android version (Android 10) and iOS version (11.0) mobile operating systems, and different features and pieces of work were assigned to different contestants in clusters. The details of the 11 clusters along with tasks, participants, and time are as follows:

4.1. Cluster-1 Screen Rotation

In this experiment, 50 contestants were nominated and assigned a piece of work to write a passage of 50 words in 5 min. Then, the effectiveness, efficiency, and satisfaction level were examined. The mission accomplishment time was detected and calculated.

4.2. Cluster-2 LED Notifications

In this mission, 50 contestants were nominated and asked to turn off their notifications for 10 min. The meeting was accompanied to find out the feelings and views of all contestants about losing emergency and non-emergency alerts/notifications. To finish, all the views were enlisted cautiously.

4.3. Cluster-3 Voice Commands

There were 50 participants nominated and a range of commands was chosen and assigned to examine. The commands were to make a phone call, open my gallery, set an alarm, and open the calculator. The time of 5 min was assigned, and then the average time was reported and kept.

4.4. Cluster-4 Swift Keyboard

An experiment was conducted in which 50 contestants were requested to use the Swift Keyboard and write five one-line SMSs using this keyboard for 5 min on their smartphone and share the accuracy level of this keyboard and average satisfaction level of all the users.

4.5. Cluster-5 S-Health

There were 50 participants invited to install any two health apps on their smartphones and they were asked to use them for 30 s as they tracked their calories, weight, sugar, blood pressure, etc. Then, the interview was accompanied and the fulfillment level was acquainted. Currently, these types of features are available in the latest devices to facilitate the users.

4.6. Cluster-6 Face Recognition

A total of 50 contestants was nominated and asked to open their phone lock using face ID, as it uses face features to recognize them. The average time given was 30 s. A review from all the contestants was taken to know their satisfaction level.

4.7. Cluster-7 Fingerprint

In this experiment, 50 contestants were nominated, and we asked them to open their phone locks using their fingerprints. The average time given was 10 s. A review from all the contestants was taken to know their satisfaction level.

4.8. Cluster-8 Gesture Recognition

Experiments were conducted and 50 contestants were requested to use different gestures on their phones. They were requested to lock and unlock the screen, use gestures on the flashlight, play the song, and take a screenshot, and they were assigned a 5 min maximum, and their time was reported.

4.9. Cluster-9 Drive Mode

There were 50 contestants nominated, and we asked them to use drive mode for 5 min while driving a car where alerts and SMS are prohibited, and the satisfaction level of contestants was witnessed.

4.10. Cluster-10 Night Mode

A total of 50 contestants was nominated to use night mode/bed mode for 5 min: it darkens the screen and makes your phone silent while you sleep. The satisfaction level was noted, and their average output was obtained.

4.11. Cluster-11 Kid Mode

An investigation was conducted in which 50 kids were involved, and all of them were school-going. They were asked to play games, draw an object, write alphabets, and do all the tasks available in the kids' space for 5 min and also use the normal mode of a smartphone to check their satisfaction level and in which form they feel comfortable using the device. Their average time was calculated. Table 2 below shows the details of different tasks and participants.

Table 2. Clusters for experimentations.

Clusters	Tasks	Subtasks	Total Participants	Total Time in Minutes	Post-Task Evaluation
Clusters 1	Screen rotation	Write a passage of 50 words	55	5 min	ASQ
Clusters 2	LED notifications	On/Off notifications	55	10 min	ASQ
Clusters 3	Voice commands	Using commands to make a phone call, open my gallery, set alarm, open calculator	55	5 min	ASQ
Clusters 4	Swift Keyboard	Send five SMSs of one line	55	5 min	ASQ
Clusters 5	S-health	Track health level	55	30 sec	ASQ
Clusters 6	Face recognition	Open phone lock	55	30 sec	ASQ
Clusters 7	Fingerprint	Open phone lock	55	10 sec	ASQ
Clusters 8	Gesture recognition	Lock and unlock the screen, use gestures on the flashlight, play a song, take a screenshot	55	5 min	ASQ
Clusters 9	Drive mode	Receive calls, open social accounts	55	5 min	ASQ
Clusters 10	Night mode	Read the text, watch a video	55	5 min	ASQ
Clusters 11	Kid mode	Play games, draw an object, write alphabets	55	5 min	ASQ

5. Usability Evaluation

Usability is a crucial factor to be measured; there are three measuring factors, e.g., effectiveness, efficiency, and satisfaction. The standards are available (ISO/IEC 9126-4 and ISO 9241-11) for usability evaluation. To know the satisfaction level, in the end, the ASQ technique was used. Errors may be accidental acts, slips, or omissions made by a user while attempting a job [18,24].

Effectiveness is about the accomplishment of goals. Equation (1) below shows the effectiveness formula.

$$Effectiveness = \frac{Total\ Number\ of\ Tasks\ Completed\ Successfully}{Total\ Number\ of\ Tasks\ Undertaken} \times 100 \quad (1)$$

Efficiency is the capability to do something well. Equation (2) shows the efficiency formula for usability evaluation.

$$Time\ Based\ Efficiency = \frac{\sum_{j=1}^{R} \sum_{i=1}^{N} \frac{n\ i\ j}{t\ i\ j}}{N\ R} \quad (2)$$

where:

N = The total number of missions;
R = The figure of users;
nij = The outcome of task i by user j, if the user productively completes the task, then;
Nij = 1, if not, then Nij = 0;
tij = The time spent by user j to complete task i. If the task is not productively completed, then time is measured till the instant the user quits the mission.

The after scenario questionnaire (ASQ) was used to check the satisfaction of users for each task [5]. The Lewis, J.R. (1995) IBM computer usability satisfaction questionnaires were followed. They consist of three questions that involve ease of doing tasks, task completion within a given time, and support information.

Usability is all about the use of the product and the situation in which it is used [38]. Here, the questionnaire technique involves a few questions which are how to complete the mission stree-free, the time it takes to complete the mission, etc [40–42].

6. Results and Discussion

The study shows that the adaptive user interface plays a crucial role; it also helps to present the usability issues in mobile phone usage. Eleven features were selected; these are LED notifications, voice commands, face recognition, fingerprint, screen rotation, kid mode, drive mode, night mode, Swift Keyboard, s-health, and gesture recognition. The three usability parameters were evaluated.

6.1. Effectiveness

The effectiveness in the usability of screen rotation is much less in adaptive than in non-adaptive situations, as it is noted that the overall effectiveness (including both male and female) of adaptive features is (45%), while in non-adaptive it is (81%). In screen rotation, keyboard adjustment in smartphones raises issues. In LED notification, it is considered that people cannot live without notifications or getting important alerts, so overall it is observed in the adaptive atmosphere (85%) and in the non-adaptive (70%). The effectiveness levels of all the features are evaluated, as shown in Figure 1.

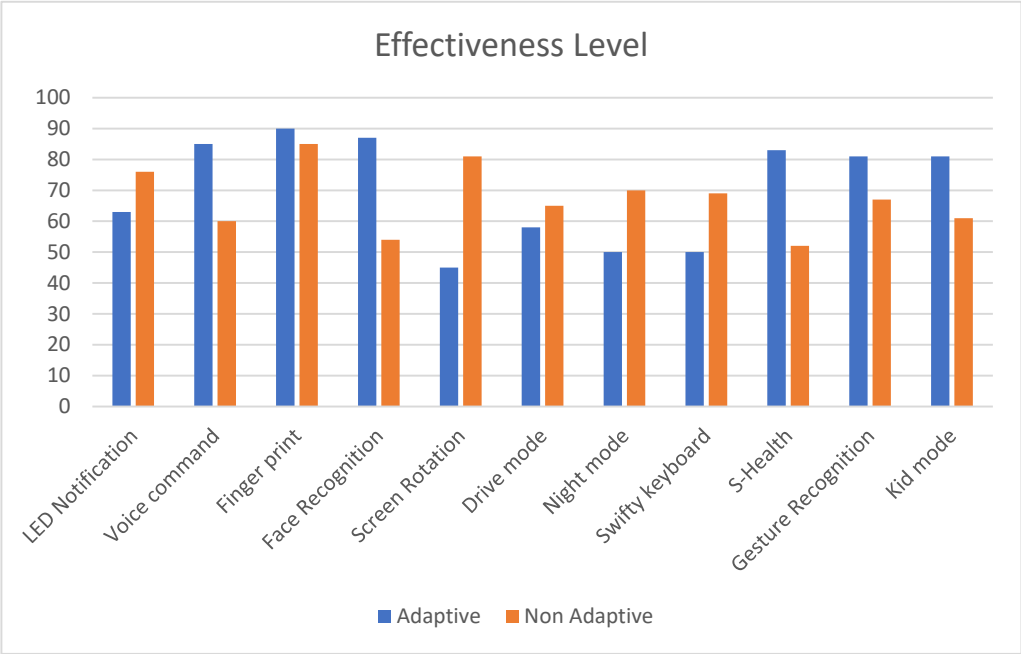

Figure 1. Effectiveness levels for adaptive and non-adaptive features.

In voice command, females do not have any issues, especially with accents, but males were not that perfect with their accent; overall, they found it easy to use, and the effectiveness in adaptive surroundings was 85%, and in the non-adaptive it was 60%. It is observed that the effectiveness level of the Swift Keyboard features was not much higher, and the reason was that the users found it difficult, as they make a lot more spelling mistakes in the adaptive (50%), and in the non-adaptive it was 69%. In s-health features, more contestants participated and found it helpful, and the effectiveness level observed in the adaptive was 83%, and the non-adaptive was 52%. It was easy to use the face recognition feature in smartphones, as it is simple and needs no effort from users. It was noted that the users were more involved, and the overall adaptive environment was 87%, and in the non-adaptive it was 54%. It was relaxing to use the fingerprint feature in the smartphones, as it is simple and needs no effort from users. It was noted that the users found it interesting; overall, the adaptive environment was 70%, and in the non-adaptive it was 60%.

Most of the users found it simple to use gestures in their smartphones to do any kind of task, so the effectiveness in the adaptive surrounding was 81%, and in the non-adaptive it was 67%. Participants used drive mode, and it was observed that while using this mode it was 58% adaptive, and in the non-adaptive it was 65%. The effectiveness of the night mode was evaluated and, overall, the adaptive atmosphere was 50%, and in the non-adaptive it was 70%. Night mode is less effective because it blocks all notifications and alerts and changes your phone to do not disturb mode. Finally, we found the effectiveness of kid mode, and it was observed that it becomes very easy for kids to use a smartphone, and they were so interested in performing tasks. They performed all tasks without any hurdles; they assigned the apps and the features they needed. So, in the adaptive environment, kid mode was 81% and 61% in the non-adaptive.

6.2. Efficiency

This graph indicates that the overall efficiency level of voice command, fingerprint, gesture recognition, kid mode, and LED notifications is more efficient than the non-adaptive features. The highest efficiency (85.48%) is shown in voice command for an adaptive feature and 81.92% for a non-adaptive feature, respectively. The lowest efficiency is shown in face recognition and s-health features. The efficiency levels of different adaptive and non-adaptive features are shown in Figure 2.

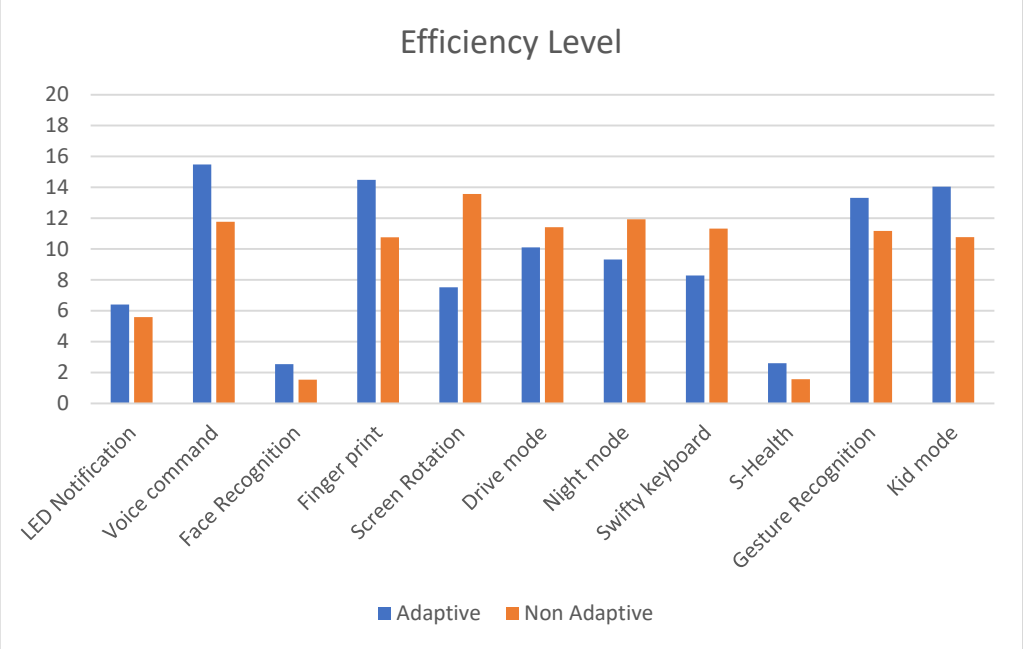

Figure 2. The efficiency levels of adaptive and non-adaptive features.

6.3. Satisfaction

Here, in Figure 3, the usability evaluation is performed to find the user satisfaction level of adaptive and non-adaptive features. ASQ was conducted for screen rotation, LED notifications, voice commands, Swift Keyboard, s-health, face recognition, fingerprint, gesture recognition, drive mode, and night mode. For kid mode, ASQ was not conducted because it is difficult for kids to answer the questions.

The satisfaction level of adaptive features such as LED notification, voice command, fingerprint, s-health, face recognition, gesture recognition, and kid mode is higher than the rest of the features, such as screen rotation, Swift Keyboard, drive mode, and night mode.

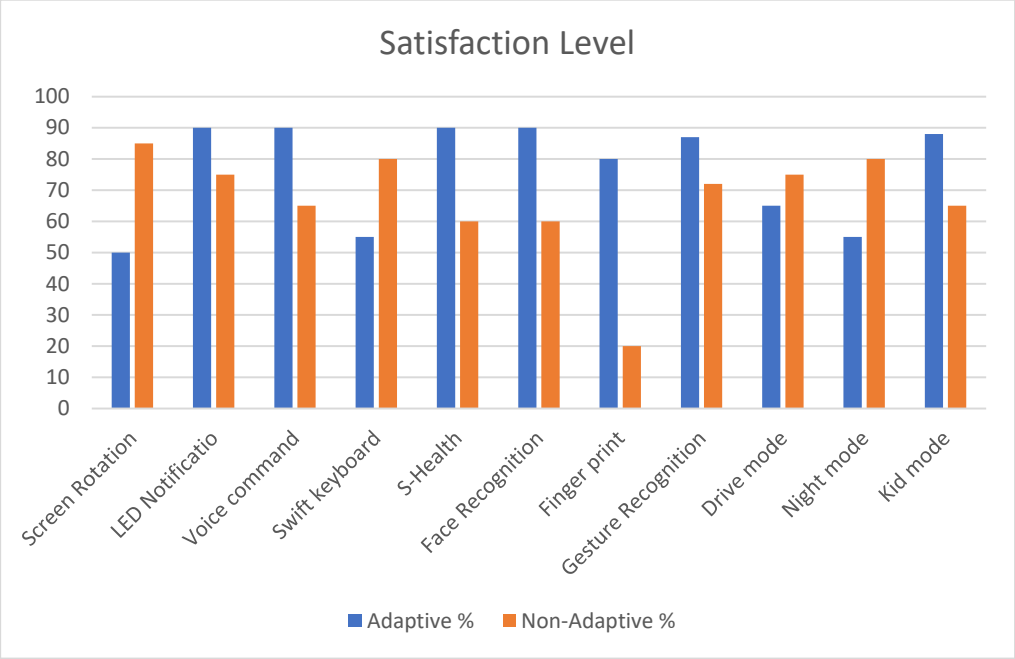

Figure 3. Satisfaction levels of adaptive and non-adaptive features.

6.4. Findings

The usability concerns with adaptivity still exist as a result of smartphone providers' standard adaptive features, independent of user ability or work context. Currently, turning on or off any adaptive feature while completing a specific task is mostly up to the user. AUI has been proposed by several researchers, each with its unique viewpoint. In today's smart world, there are several variants in terms of user, task, environment, and device. These differences in the usage environment are rapidly rising, and a single interface will not be able to accommodate them. As a result, developing custom interfaces for each environment independently is difficult. This study provides significant results of adaptive and non-adaptive features for smartphones. Furthermore, there is still a dire need to develop smartphone features according to user context to provide easiness.

7. Conclusions and Future Work

In this paper, our basic purpose was to find out the usability of adaptive features in smartphones. The effectiveness, efficiency, and satisfaction level of different adaptive features were evaluated. User-centered designs (UCD) was monitored to know the usability of available adaptive features. Features such as LED notification, voice command, fingerprint, s-health, face recognition, gesture recognition, and kid mode were observed to be more effective than screen rotation, Swift Keyboard, drive mode, and night mode. The reason is that participants found it difficult to use these features. It was discovered that usability problems with adaptiveness still exist as a result of smartphone vendors' uniform adaptive features, regardless of user capacity or task context. Currently, turning on or off any adaptive function when performing a particular task is entirely up to the user. The results of the experiment show that user adaptivity is high when used in the right way, and interfaces have a greater potential to boost mobile usability. It is proposed that to boost the usability of smartphones, the interface should have more adaptive features. For moving to any adaptive environment, it is also suggested that the user and task context be studied or sensed. These results are also applicable to the adoptive features of other devices such as laptops, tablets, computers, etc., in the same manners. Future work may include user and task context analysis, as well as mapping of adaptive functionality to them. Additionally, model based on UCD, context analysis, and mapping functions will be created.

Author Contributions: Conceptualization, H.R., M.U.A. and A.A. (Abdullah Alshahrani); data curation, M.W.I.; formal analysis, H.R.; funding acquisition, A.M.A., A.A. (Abdullah Alshahrani), and A.A. (Adel Alshamranii); investigation, M.U.A. and A.A. (Adel Alshamranii); methodology, A.M.A., H.R. and M.U.A.; project administration, A.M.A. and M.U.A.; resources, M.U.A. and A.A. (Abdullah Alshahrani); supervision, M.W.I., M.U.A. and A.A. (Adel Alshamranii); validation, M.W.I.; visualization, M.W.I.; writing—original draft, A.M.A. and H.R.; writing—review and editing, A.M.A., M.W.I., M.U.A., A.A. (Abdullah Alshahrani), and A.A. (Adel Alshamranii). All authors have read and agreed to the published version of the manuscript.

Funding: This work was funded by the University of Jeddah, Jeddah, Saudi Arabia, under grant No. (UJ-22-DR-14).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors acknowledge with thanks the University of Jeddah's technical and financial support.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Wang, D.; Xiang, Z.; Fesenmaier, D.R. Smartphone use in everyday life and travel. *J. Travel Res.* **2016**, *55*, 52–63. [CrossRef]
2. Stroud, N.J.; Peacock, C.; Curry, A.L. The effects of mobile push notifications on news consumption and learning. *Digit. J.* **2019**, *8*, 32–48.
3. Ahmed, S.; Balasubramanian, H.; Stumpf, S.; Morrison, C.; Sellen, A. Investigating the intelligibility of a computer vision system for blind users. In Proceedings of the 25th International Conference on Intelligent User Interfaces, Cagliari, Italy, 17–20 March 2020; Volume 1, pp. 419–429.
4. Andone, I.; Błaszkiewicz, K.; Eibes, M.; Trendafilov, B.; Montag, C.; Markowetz, A. How age and gender affect smartphone usage. In Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp), Heidelberg, Germany, 12–16 September 2016; Volume 1, pp. 9–12.
5. Iqbal, M.W.; Ahmad, N.; Shahzad, S.K. Usability evaluation of adaptive features in smartphones. In Proceedings of the International Conference on Knowledge Based and Intelligent Information and Engineering Systems, (KES), Marseille, France, 6–8 September 2017; Volume 1, pp. 2185–2194.
6. Győrödi, R.; Zmaranda, D.; Adrian, V.G.; Gyorodi, C. A Comparative Study between Applications Developed for Android and iOS. *Int. J. Adv. Comput. Sci. Appl.* **2017**, *8*, 176–182. [CrossRef]
7. Bauer, M.; Glenn, T.; Geddes, J.; Gitlin, M.; Grof, P.; Kessing, L.V. Smartphones in mental health: A critical review of background issues, current status, and future concerns. *Int. J. Bipolar Disord.* **2020**, *8*, 1–19. [CrossRef] [PubMed]
8. Amez, S.; Baert, S. Smartphone use and academic performance: A literature review. *Int. J. Educ. Res.* **2020**, *103*, 101618. [CrossRef]
9. Anam, R.; Abid, A. Usability Study of Smart Phone Messaging for Elderly and Low-literate Users. *Int. J. Adv. Comput. Sci. Appl.* **2020**, *11*, 1–14. [CrossRef]
10. Kula, H.; Ayhan, C.; Soyer, F. The Relationship Between Smartphone Addiction and Life Satisfaction: Faculty of Sport Sciences Students. *Int. J. Psychol. Educ. Stud.* **2020**, *7*, 86–95. [CrossRef]
11. Memon, I.; Ali, Q.; Fazal, H.; Zubedi, A.; Khuwaja, S.S. Concepts, analysis, issues of smartphone and smart devices: A survey. In Proceedings of the IEEE 3rd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), Sukkur, Pakistan, 29–30 January 2020; Volume 1, pp. 1–8.
12. AlQarni, M.A.; Chauhdary, S.H.; Malik, M.N.; Ehatisham-Ul-Haq, M.; Azam, M.A. Identifying smartphone users based on how they interact with their phones. *Hum. Cent. Comput. Inf. Sci.* **2020**, *10*, 1–14. [CrossRef]
13. Thakur, S.S.; Roy, R.B. Predicting mental health using smart-phone usage and sensor data. *J. Ambient Intell. Humaniz. Comput.* **2020**, *12*, 9145–9161. [CrossRef]
14. Gonçalves, V.P.; de Almeida Neris, V.P.; Seraphini, S.; Dias, T.C.M.; Pessin, G.; Johnson, T.; Ueyama, J. Providing adaptive smartphone interfaces targeted at elderly people: An approach that takes into account diversity among the elderly. *Univers. Access Inf. Soc.* **2015**, *16*, 129–149. [CrossRef]
15. Novac, O.C.; Novac, M.; Gordan, C.; Berczes, T.; Bujdosó, G. Comparative study of google android, apple iOS and microsoft windows phone mobile operating systems. In Proceedings of the 2017 14th International Conference on Engineering of Modern Electric Systems (EMES), Oradea, Romania, 1–2 June 2017; Volume 1, pp. 154–159.
16. Brunette, M.; Achtyes, E.; Pratt, S.; Stilwell, K.; Opperman, M.; Guarino, S.; Kay-Lambkin, F. Use of smartphones, computers and social media among people with smi: Opportunity for intervention. *Community Ment. Health J.* **2019**, *55*, 973–978. [CrossRef] [PubMed]

17. Lahiani, H.; Elleuch, M.; Kherallah, M. Real time hand gesture recognition system for android devices. In Proceedings of the 2015 15th International Conference on Intelligent Systems Design and Applications (ISDA), Marrakech, Morocco, 14–16 December 2015; Volume 1, pp. 591–596.
18. Weichbroth, P. Usability of Mobile Applications: A Systematic Literature Study. *IEEE Access* **2020**, *8*, 55563–55577. [CrossRef]
19. Liu, W.; Lee, K.-P.; Gray, C.M.; Toombs, A.L.; Chen, K.-H.; Leifer, L. Transdisciplinary Teaching and Learning in UX Design: A Program Review and AR Case Studies. *Appl. Sci.* **2021**, *11*, 10648. [CrossRef]
20. Jeong, J.; Kim, N.; In, H.P. Detecting usability problems in mobile applications on the basis of dissimilarity in user behavior. *Int. J. Hum. Comput. Stud.* **2020**, *139*, 102–364. [CrossRef]
21. Yigitbas, E.; Jovanovikj, I.; Biermeier, K.; Sauer, S.; Engels, G. Integrated model-driven development of self-adaptive user interfaces. *Softw. Syst. Model.* **2020**, *19*, 1057–1081. [CrossRef]
22. Baqeel, H.; Saeed, S. Face detection authentication on smartphones: End user's usability assessment experiences. In Proceedings of the International Conference on Computer and Information Sciences (ICCIS), Sakaka, Saudi Arabia, 3–4 April 2019; Volume 1, pp. 1–6.
23. Norman, D.A.; Draper, S.W. User centered system design: New perspectives on human-computer interaction. *Am. J. Psychol.* **1986**, *101*, 148.
24. Shareef, S.; Khan, M.N.A. Evaluation of usability dimensions of smartphone applications. *Int. J. Adv. Comput. Sci. Appl.* **2019**, *10*, 426–431. [CrossRef]
25. Zheng, M.; Cheng, S.; Xu, Q. Context-based mobile user interface. *J. Comput. Commun.* **2016**, *4*, 1–9. [CrossRef]
26. Gao, H.; Groves, P.D. Environmental context detection for adaptive navigation using GNSS measurements from a smartphone. *Navig. J. Inst. Navig.* **2018**, *65*, 99–116. [CrossRef]
27. Iqbal, M.W.; Ahmad, N.; Shahzad, S.K.; Feroz, I.; Mian, N.A. Towards adaptive user interfaces for mobile-phone in smart world. *Int. J. Adv. Comput. Sci. Appl.* **2018**, *9*, 556–565. [CrossRef]
28. Cheng, Y.; Ji, X.; Li, X.; Zhang, T.; Malebary, S. Identifying child users via touchscreen interactions. *ACM Trans. Sens. Netw.* **2020**, *16*, 1–25. [CrossRef]
29. Solecki, S. The smart use of smartphones in pediatrics. *J. Pediatr. Nurs.* **2020**, *55*, 6–9. [CrossRef] [PubMed]
30. Oviedo-Trespalacios, O.; Vaezipour, A.; Truelove, V.; Kaye, S.-A.; King, M. They would call me, and I would need to know because it is like life and death': A qualitative examination of the acceptability of smartphone applications designed to reduce mobile phone use while driving. *Transp. Res. Part F Traffic Psychol. Behav.* **2020**, *73*, 499–513. [CrossRef]
31. Oviedo-Trespalacios, O.; King, M.; Vaezipour, A.; Truelove, V. Can our phones keep us safe? A content analysis of smartphone applications to prevent mobile phone distracted driving. *Transp. Res. Part F Traffic Psychol. Behav.* **2010**, *60*, 657–668. [CrossRef]
32. Oh, J.H.; Yoo, H.; Park, H.K.; Do, Y.R. Analysis of circadian properties and healthy levels of blue light from smartphones at night. *Sci. Rep.* **2015**, *5*, 11325. [CrossRef]
33. Kumar, P.M.; Gandhi, U.; Varatharajan, R.; Manogaran, G.; Vadivel, T. Intelligent face recognition and navigation system using neural learning for smart security in internet of things. *Clust. Comput.* **2017**, *22*, 7733–7744. [CrossRef]
34. Wang, Z.; Hou, Y.; Jiang, K.; Dou, W.; Zhang, C.; Huang, Z.; Guo, Y. Hand gesture recognition based on active ultrasonic sensing of smartphone: A survey. *IEEE Access* **2019**, *7*, 111897–111922. [CrossRef]
35. Sarker, I.H. Context-aware rule learning from smartphone data: Survey, challenges and future directions. *J. Big Data* **2019**, *6*, 1–25. [CrossRef]
36. Visuri, A.; van Berkel, N.; Okoshi, T.; Goncalves, J.; Kostakos, V. Understanding smartphone notifications' user interactions and content importance. *Int. J. Hum. Comput. Stud.* **2019**, *128*, 72–85. [CrossRef]
37. Srinivasan, M. Voice controlled home automation by using bluetooth module. *Int. J. Res. Appl. Sci. Eng. Technol.* **2018**, *6*, 3222–3227. [CrossRef]
38. Sarker, I.H.; Colman, A.; Han, J.; Khan, A.I.; Abushark, Y.B.; Salah, K. BehavDT: A behavioral decision tree learning to build user-centric context-aware predictive model. *Mob. Netw. Appl.* **2019**, *25*, 1151–1161. [CrossRef]
39. Okoshi, T.; Tsubouchi, K.; Tokuda, H. Real-world product deployment of adaptive push notification scheduling on smartphones. In Proceedings of the 25th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining, Anchorage, AK, USA, 4–8 August 2019; pp. 2792–2800.
40. Hamid, K.; Iqbal, M.W.; Muhammad HA, B.; Fuzail, Z.; Tabassum, Z. Usability evaluation of mobile banking applications in digital business as emerging economy. *Int. J. Comput. Sci. Netw. Secur.* **2022**, *22*, 250–260.
41. Hamid, K.; Iqbal, M.W.; Muhammad, H.; Fuzail, Z.; Ahmad, Z. Anova Based Usability Evaluation of Kid's Mobile Apps Empowered Learning Process. *Qingdao Daxue Xuebao Gongcheng Jishuban J. Qingdao Univ. Eng. Technol. Ed.* **2022**, *41*, 142–169.
42. Hamid, K.; Iqbal, M.W.; Nazir, Z.; Muhammad, H.A.B.; Fuzail, Z. Usability empowered by user's adaptive features in smart phones: The rsm approach. *Tianjin Daxue Xuebao J. Tianjin Univ. Sci. Technol.* **2022**, *55*, 285–304. [CrossRef]