Chapter 5
Usability Attributes for Mobile Applications: A Systematic Review

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Abstract The usability of mobile applications (apps) is an emerging area of research because of the increasing use of mobile devices around the world. App development is challenging because each application has its own purpose, and each individual user has different needs and expectations from the apps. There are various apps available for each purpose, and the success of the application depends on its usefulness. This paper presents a systematic review of some of the most contemporary apps and highlights their usability attributes. It discusses usability models, frameworks and guidelines outlined in previous research for designing apps with enhanced usability characteristics. Based on this research, comprehensive guidelines for mobile apps' usability can then be provided.

5.1 Introduction

The traditional usability guidelines used in desktop applications are not very much applicable to the apps [1]. App usability attributes are different; therefore, we need to specify usability attributes that are essential and important for apps [2]. The important usability attributes expected in any app are effectiveness, satisfaction, efficiency, learnability, errors and memorability as well as the quality characteristics outlined in ISO 9126 [3–6]. Some of the usability attributes may overlap in meaning but have been used with different names by different researchers.

Most of the guidelines are for usability testing, but most of them are not applicable to apps because mobile apps have unique features and changing context [1]. Furthermore, the work available does not have any consensus on the factors of usability. A recent study identified user, task and context as the main factors of usability [3]. However, the study was lacking due to certain limitations. The

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researchers found it hard to find the relevant papers, and it affected the results. The papers included were from 2008 to 2010 because smartphone apps had become popular during this period and there had not been much research done on mobile apps usability till that time. A review was conducted on usability characteristics of apps, but the work also lacked some of the recent developments in apps' usability [7].

This article seeks to contribute to important research concerning the usability attributes of apps. The purpose of this research is to conduct a systematic review that reveals the most prominent and recent usability attributes that have been discussed and have emerged in the research. This study will be useful in building future guidelines for developing apps that have all the essential usability attributes. This work stands out because it discusses some of the most contemporary research.

5.2 The Systematic Review

We undertook a systematic review to search for published, peer-reviewed articles that investigated usability attributes in mobile apps. We utilised the terminology outlined in the table below (Table 5.1) to look for research papers covering usability attributes in mobile devices and applications. We sought to incorporate all the related terms that could provide us with articles relevant to this topic.

We referred to ACM Digital Library, EBSCO, IEEE Xplore, PsycINFO, Communication and Mass Media Complete, Computers and Applied Sciences Complete, ProQuest Computer Science Collection, Computer Source and Web of Science.

We tried to include the most recent articles starting from 2010, which were based on app usability. We have followed the methodology from [8], and the flow chart below shows how the systematic review was undertaken (Fig. 5.1).

Table 5.1 Keywords used in the systematic review relating to usability attributes of mobile applications

| Search lines	Search terms	Filtered by
Line 1	Mobile device or mobile phone or smart phone	Title/abstract
Line 2	Applications or apps	Title/abstract
Line 3	Usability	Title/abstract
Line 4	Mobile application usability or mobile app usability	Title/abstract
Line 5	Application usability attributes or apps usability attributes	Title/abstract
Line 6	Mobile application usability attributes or mobile apps usability attributes	Title/abstract
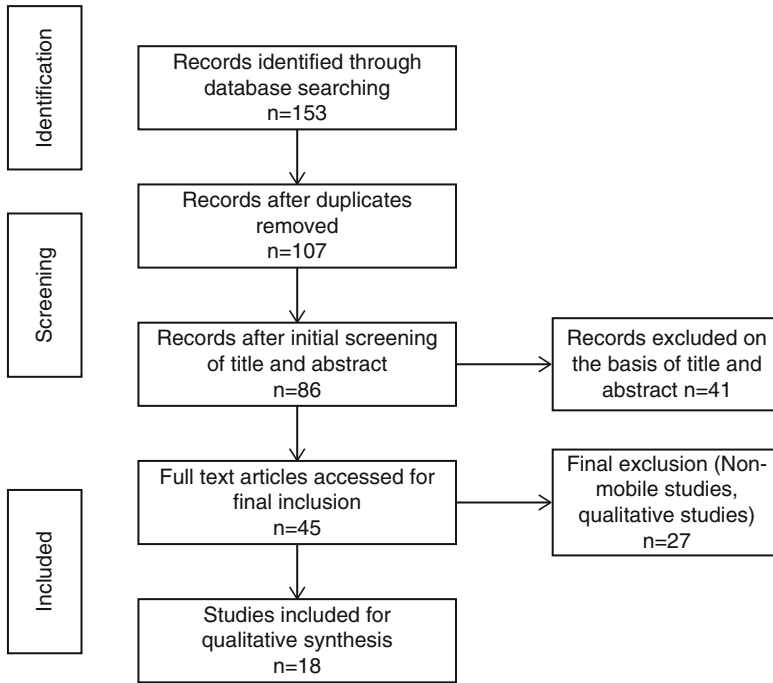
Fig. 5.1 Methodology for the systematic review

5.3   Results

We conducted a systematic review of usability attributes in mobile apps. We looked for articles that discussed usability attributes in mobile devices and applications. We also conducted a comprehensive survey on usability of apps and tried to figure out the important attributes discussed in these papers. Eighteen relevant articles were included which have been published and peer reviewed (Table 5.2).

5.4   Results Evaluation

Figure 5.2 shows the mobile apps' usability attributes. Satisfaction is the most highly mentioned amongst studies at ten times and then both effectiveness and efficiency at six times. Next, learnability was cited three times. Afterwards, simplicity, usefulness, errors, understandable and attractiveness were named two times. All the other attributes, such as memorability and cognitive load, were only cited once.

Table 5.2 Usability attributes in apps

Study's date	Usability attributes	Research
2010	Enjoyment, usefulness and ease of use	A new user interface (UI) for mobile phones is presented in this article, which makes the use of UGC services both more efficient and easier. UI has two main mobile Web 2.0 technologies, multi-display buttons and tag and tag cloud, which increase the flexibility of individual users' buttons and display size. The article not only describes the new UI interface but also investigates whether it aids in enhancing exploratory browsing within mobile user-generated content (UGC) services [9]
2010	Network connection quality, user distraction and user mobility	The article aims to fill a gap in the field of mobile information technology by coming up with clear guidelines for designing mobile information systems. Building on prior studies this research introduces a three-step conceptual model that can be used by managers to design effective information systems. The research found that a network connection's poor quality and high user distraction are very challenging features for mobile information system (IS) design; user interface should be given particular attention [10]
2010	Menu icons, text and colour	This article studied the effects of product aesthetics in usability testing on various outcome variables. The research asked whether changing the appearance of mobile phones has an impact upon usability. Sixty adolescents were asked to use two functionally identical mobile devices but with different visual appearances (highly appealing or not appealing) to find out if there is any relation between usability, perceived attractiveness and performance measures of the product. The findings were that the appealing appearance has a more highly perceived usability, perceived product attractiveness and user performance due to lower task completion time, less errors and higher interaction efficiency [11]
2011	Presentation, adaptation of Web pages, accuracy and search time	The researchers developed and tested specific mobile apps in lab research settings. Testers' performances were used to evaluate usability attributes. The results of the research showed that presentation adaptation greatly enhanced user perception and performance of mobile Web browsing. They discovered that less complexity in information search tasks improves accuracy and reduces search time [12]
2011	Icon characteristics	The study aimed to find out how mobile devices could be made easier to use for adults over 65 years of age. Specifically, alternative mobile apps were benchmarked by manipulating icon characteristics. It was found that the elderly face more problems using icons on existing mobile devices. However, icon characteristics, which have a close semantic meaning (i.e. a close relationship between the portrayed object and its connected function) and are well-known and specific were found to enhance and improve icon usability for elderly people [13]

Year	Attributes	Description
2012	Customer needs, design, feedback, innovativeness, satisfaction and efficiency	This research developed and used a questionnaire on mobile phones to find out if there was any relationship between usability and the success of the product. The researchers reviewed the factors of product success and existing usability studies to develop a questionnaire. The usability and success factors of mobile phones were evaluated by the participants. The results showed that customer needs, design and innovativeness were not only important success factors but also increased attention ought to be given to feedback, efficiency and satisfaction to improve the usability of mobile phones [14]
2012	Screen size, colour, weight of device, text source, extra batteries, etc.	This paper aims to highlight the expected quality characteristics of apps with a detailed and reviewed discussion mostly about usability characteristics, being external characteristics of apps as according to ISO 9126 [7]
2013	Errors, task completion time and effectiveness	The article compares mobile usability in Iran and Turkey. The research concludes that usability is impacted by not only religious, ethnic or cultural issues but also contextual features which are endemic to both Turkey and Iran [15]
2013	Efficiency, satisfaction, effectiveness, aesthetic, usefulness, simplicity, learnability, understandable, intuitiveness and attractiveness	The main objective of the study is to propose a set of usability dimensions that should be considered when evaluating and designing mobile apps. The model introduced is based on the reviews of previously related studies, which were analysed by using a content analysis approach. Ten usability attributes were outlined in the model. The model introduced could be of assistance to practitioners and researchers as a guideline to design usable mobile apps [16]
2013	Security	The paper discusses the relationship between security and usability in mobile platforms; and how reducing various security threats can improve the usability of mobile apps [17]
2013	How the satisfaction attribute of apps can be improved by making them more energy efficient	The approach proposed in the paper is convenient for developers and provides a better estimate of energy consumption at code level. Pre-instruction energy modelling and program analysis are used to achieve these results. The new approach can estimate energy consumption for mobile apps to 10% of the ground truth [18]

Table 5.2 (continued)

Study's date	Usability attributes	Research
2013	Efficiency, satisfaction, effectiveness, learnability, errors, memorability and cognitive load	Review of usability models was conducted and outlined seven usability attributes. The researchers believed cognitive load has been overlooked in previous usability models [3]
2014	Efficiency, user satisfaction and technical effectiveness	The research objective was to test the usability (efficiency, user effectiveness and technical effectiveness) of a developed mobile app (Reactivate) in obese adolescents. A field study was conducted on obese children who were asked to use the app to perform tasks to test its usability. The tasks had five categories: to create a message, to enter personal settings, to use the goal-setting feature, to find and to answer surveys and to enter descriptions or details of weight and height. Standardized SUMI was completed by each participant to determine the satisfaction of the user. SUMI measures five aspects of user satisfaction: effect, controllability, helpfulness, efficiency and learnability. SUMI scores and the mean relative user efficiency were explored using descriptive statistics. The mean scores confirmed that reactivate was a useful app, and users responded with great interest [19]
2015	Satisfaction	People with ASD (autism spectrum disorder) usually lack familiarity and experience with new technologies; therefore, usability of apps developed specifically for children with autism is very important. The paper compares the usability of two Arabic apps available on the Apple Store. Various measurement tools were used to collect quantitative and qualitative data to determine the level of user satisfaction with the apps. Recommendations were then made on how further the usability of these apps can be improved [20]

| Year	Attributes	Description
2015	Efficiency effectiveness, satisfaction, attractiveness, learnability, operability and understanding	This paper conducted a systematic literature review to investigate empirical usability evaluation processes described in different m-health app studies. The research showed that the usability attributes evaluated mostly in m-health apps were operability and effectiveness. The results showed that using automated mechanisms can improve the methods of empirical evaluation employed in usability. The paper could be useful for developers and researchers who are looking to create apps with better usability. The study also demonstrates the benefits of adapting health apps to the needs of users [21]
2015	Efficiency, effectiveness and satisfaction	This paper aimed to assess the usability of Chongqing University Library App and give recommendations for improving the usability of apps. Usability testing involved pretest questionnaires, achieving tasks and posttest surveys. Three attributes were measured: effectiveness, efficiency and user satisfaction. The results showed that app was effective, but improvement was needed for efficiency. For the user satisfaction, 'usefulness' had the highest score and 'clarity' the lowest. The descriptions were not clear and sometimes confused users. However, the services the app provided were appealing and appreciated by most users. After measuring UX, the paper recommends ways to enhance the usability of the app [22]
2016	Visibility, scrolling, navigation, interaction, satisfaction, convenience and simplicity	The paper compared four widely used mobile spreadsheet apps: Google Drive, Documents to Go, OfficeSuite Viewer 6 and ThinkFree Online. Measures for each usability attribute were gleaned from a survey. These surveys were created to address the measures based on comparative criteria supplied in the analysis. The results also indicate that there is little difference between the apps in their end results and the aspects conducted in this survey [23]
2016	Satisfaction and user feeling	The article selects all touchscreen mobile devices and various components that affect their usability. Analytic network process (ANP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) were used to find which mobile devices were superior and which usability features were most important [24]

Usability Attributes
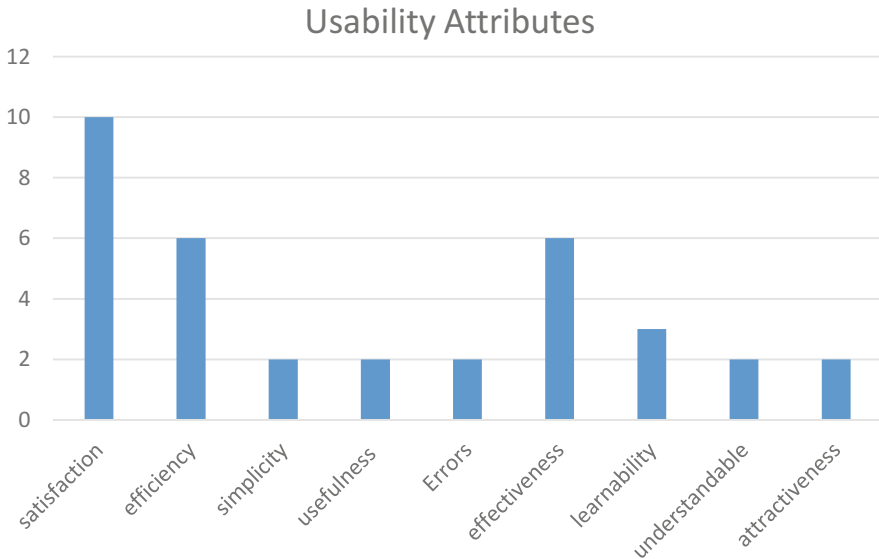
Fig. 5.2 Usability attributes in mobile apps

5.5   Conclusion

This review shows that usability in apps has been discussed from various points of view by many authors. Some studies provide guidelines for improving usability, whilst others compare usability attributes amongst different apps. Usability has been discussed from numerous angles between 2010 and 2016. Most of the work discussed in the beginning of the study involved research in lab settings; however more recent research usually took place in field settings. Earlier research was aimed at testing usability attributes in apps or emphasising the importance of certain attributes. Next, most researchers were interested in comparing different applications to test usability. Then, usability attributes have been evaluated for some practical apps, and there has been a focus on adding something new to these. Recent work has also included users' acceptance and expert reviews as evaluating procedures for determining the usability of applications. Some of the recent work focuses specifically on improving usability in apps related to various fields ranging from health to social networking. Usability criteria are always evolving, and the needs of people are changing rapidly so new dimensions of usability have been discussed in some of the recent research. The attributes that are emerging in the new research are related to the ease of use of the application when performing multiple tasks, intuitiveness, security and power consumption. These attributes can be debated as being part of those defined in the traditional literature, but in apps, there is a need to mention them separately to emphasise their importance.

The evaluation of the results shows that satisfaction is the most highly mentioned amongst studies at ten times followed by both effectiveness and efficiency at six times.

This research shows that there are numerous usability attributes and it is difficult for designers to include them all into one app. The best they can do is improve the usability of the app by keeping its nature in mind. This research will be used to outline usability guidelines for developing applications with enhanced usability. This is only possible when the developer is aware of the attributes that enhance usability.

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