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Research paper



Usability Guidelines for Designing Mobile Apps User Interface for Children with Autism: a Systematic Literature Review

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Abstract

In the recent years major advancement in technologies that support the children that have been diagnosed with the autism. The increasing number of application is to enhance their ability in communication, understanding, and interface with others. There are over 200 mobile applications for autistic children that can be found in the current market. However, these mobile applications did not use standard guidelines which cause some difficulties to use and learn by the autistic children. This is because of the lack of usability guidelines for mobile application which are relatively unexplored and unproven. There are 142 publications obtained by the automatic searched and 23 relevant studies have been selected as the primary studies. The process was achieved with manual searches using keywords and snowballing techniques to identify the usability factors. This systematic review investigates on the study of the existing usability factors that frequently have been used in designing mobile application for autistic children. It was found that understandable and appearance were included as the usability factors due to their relevancy towards the characteristics of the autistic children. The results are useful for future enhancement in this field to develop usability guideline in designing mobile application user interface in different fields.

Keywords: *Autism, mobile application, usability factors, usability guidelines, user-interface design.*

1. Introduction

According to Ministry of Health [1] and National Autism Society of Malaysia [2], there are increasing number of autism since 2006 to 2013 approximately 9000 children in Malaysia and 47000 Malaysian (below age 20) is autistic and the trend is increasing from time to time by 3%. Autism is a subclass of the Autism Spectrum Disorder (ASD) which is basically can be defined as a type of mental disabilities during early childhood that affect person's abilities in emotional, learning, communication, memory and interaction [3-10]. Some researchers say that it is a neurological disorder that affect their brain to process the information in different ways based on the environment which cause them to behave strangely [11-13]. Due to their (autism) disabilities, they have failed to develop peer relationships, delayed in speech development, poor eyes contact and rigid adherence to routines [13]. Thus, early intervention is needed in order to help them to improve their affected abilities. Early intervention able to build their strength to improve their behaviours, teach new skills and remediate area of weakness by providing with clear instruction.

Recently, the evolution of mobile technology has changed the way people communicate, handling their daily basis, and conduct businesses. Even the disable people will also be affected by the rapid advancement of the mobile technology. Mobile phones today are equipped with various type of features and advanced computing that can give benefits to multiple domains from the usage of mobile application. The mobile applications need to be useful but usable due to its ability to support various spectrum of users including both normal and disabilities people.

There are over 200 mobile applications that can be found in the current market today that focus more towards the autistic children. Usability is defined as the capability of the product that has attribute of the particular software in fulfilling the need of the user to learn and understand the system to achieve certain goal effectively and efficiently. Normally, usability of a product is shown through its interface by following a number of usability guideline and standards that have been introduced. This is to ensure the system will meet the quality. Therefore, it is a need to have suitable usability factors that can be used in designing interface of mobile application for autistic children.

In this paper, we will discuss the existing usability factors that currently have been used for interface design of mobile application for autism. The objective of reviewing literature is to introduce proper guidelines for mobile applications for autistic children. Thus, this paper is to represent systematic literature review of the usability factors and future work. This paper will be organized as follow: Section 2 will describe the methodology. Section 3 describes finding upon the gaps based on the usability guideline for mobile application of autism. Section 4 will offer discussion upon the results. Section 5 provides the conclusion of the study and future works.

2. Systematic Literature Review

In this study, systematic literature review has been conducted as a technique for data gathering due to its ability in gathering the gaps and the challenges of this research by narrowing down the suitable usability factors that can be used in designing interface of a mobile application for autism. Thus, Fig.1 systematic literature review methodology will follow the guideline proposed by Okoli[14].

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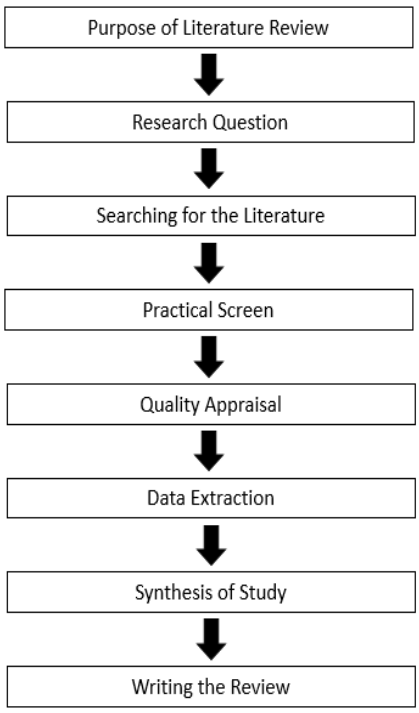


Fig. 1: Systematic Literature Review Methodology

2.1. Purpose of Literature Review

The purpose of conducting the systematic literature review is to study the usability factors and identify the common usability factors that have been used by the researcher in designing the interface for a mobile application for autistic children. There are eight (8) phases involve in conducting the systematic literature review based on the reference guideline.

2.2. Research Question

Basically, the aim of the study is to answer following research question (RQ):
RQ: Which usability factors that frequently used by the practitioners or researchers (for mobile app design for autism)?
In RQ, it has been concerned to start the search for the studies at the start of 2011. The researcher needs to consider the existing usability factor that currently has been used by another researcher in order to design an interface of a mobile application for autism. Usability factor is essential in designing and developing an application for various devices which able to give a good experience to the users.

2.3. Searching for the Literature

To conduct the review, several steps is needed to be taken and one of them is to search for the published journal and research articles/papers. Basically, the process of searching the publication will be conducted manually from group sites of the author who conduct research in the related field through conferences papers, books and all the available online databases; IEEE, ACM Digital Libraries, Scopus, Science Direct, and Google Scholar.
The reviews that have been performed are based on the multiple databases in order to minimize the relevant studies. The keywords used in the searching "usability factors", "mobile application"," autism", "usability guideline", "special needs" and "interface design". The articles extracted were published from the year 2009 until 2017 which focus on the interface design criteria that related to the autism disorder. The data were analysed to determine the existing usability factors that have currently been used for mobile application for autism.
The searching process has redirected to 142 publication. As we analysed the title, abstracts, also introduction and conclusion obtained from each database, only the relevance paper that will be extracted. However, based on the relevant papers that have been extracted only 23 papers will be analysed according to the related domain. As a result, the general guidelines in this study will be originated based on the usability factors that have been identified.

- question affected quality issues that have been focused on by the study; N, unclearly quality assessment of individual primary studies has been experimented.

2.4. Practical Screen

The process of selecting related papers is based on the exclusion and inclusion criteria below:
Peer reviewed articles from the following topics, which published between 1st January 2011 and 31st December 2017 were included and also we included the articles that have one element of literature review as well as the literature review was the main objective of the articles:

- The research studies on the usability factors in designing the interface of a mobile application for autism.
- Studies on the usability guideline of interface design of mobile application for autism
- Discuss the interface design elements that require in the usability guideline to design interface of a mobile application for autism.
- Studies on the motivational of the autism towards the interface design of autism mobile application

As for the exclusion, studies on the following topics will be excluded.

- The research studies are not based on full development of the mobile application

2.5. Quality Appraisal

In this study, the articles has been evaluated using the Database of Abstracts of Reviews of Effects (DARE) from York University, Centre for Reviews and Dissemination (CDR)[15]. TABLE 1 below are the following criteria based on the four quality evaluation (QE) questions?

Table 1: Quality Evaluation Questions

ID	Quality Evaluation Questions
QE1	Are the review's inclusion and exclusion criteria described and appropriate?
QE2	Is the literature search likely to have covered all relevant studies?
QE3	Did the reviewers assess the quality/validity of the included studies?
QE4	Were the basic data/studies adequately described?

Below is how the questions were scored.

- QE1: Y (yes), the inclusion criteria are clearly defined in the study, P (Partly), the inclusion criteria are unexpressed; N (no), the inclusion criteria are undefined and implicit.
- QE2: Y, the researchers have either search 4 or more digital libraries and included extra search techniques or distinguished and referenced all journals that focus on the topic of interest. ; P, the researchers have searched 3 or 4 digital libraries with no additional search techniques, or searched a defined but limited set of journals and conference proceedings; N, the researchers have search up to 2 digital libraries or an uncommonly restricted set of journals.
- QE3: Y, the researchers have clearly described quality criteria and obtain them from each primary study; P, the research

- QE4: Y, information is clearly presented about each study; P, only brief information about primary studies is presented; N, the results of the individual primary studies are not clearly defined.

The scoring method was Y = 1, P = 0.5, N = 0. The researchers facilitated the quality evaluation extraction process. The researchers evaluated every paper and was scored. Hence, the quality evaluation score of each publication is defined based on the number of Ys.

2.6. Data Extraction

Below are the data extracted from the research study according to Barbara Kitchenham[16]:

- The source (journal or conference) and full reference.
- Scope (Research trends or specific technology evaluation question or domain).
- Main topic area.
- The author(s) and their institution and the country where it is situated.

Brief of the study including the main research questions and the answers.

- Research question/issue.
- Quality evaluation.

The information have been extracted and analysed to ensure that it covers the focused topics.

2.7. Synthesis of Study

Below are the data that have been gathered throughout the process of conducting the systematic literature review. The data was tabulated to show the following information.

- Author of the studies
- Domain of the research studies
- Method that has been conducted in the research studies
- Contribution to the research
- Limitation of the research
- Usability factors that have been used in the research studies

2.8. Writing the Review

These are the 23 selected paper that have been analysed and the data that has been gathered in this study is presented in TABLE 2

Table 2: Systematic Review Studies Concept Matrix

ID	Author	Method	Usability Factors	Domain	Contribution	Limitation
S1	Hu [17]	The Use of Three Input Techniques	Success Rate, Efficiency	Cognitive Disabilities		
S2	Navarro et al. [18]	Technological and Pedagogical Approach	Design, Navigation, Customization, Feedback, Motivation,	Normal Students	Number of papers in the area have increased significantly Since 2013	52% of the analysed applications used a usability test only 44% are based on heuristic evaluations or revised by experts.
S3	Blackburn [19]	The Design Science Navigation and Editing Support-Model of Interface for Braille Keyboard Devices	Easy to Use, Efficiency, Satisfaction	Visual Impaired	Contributes to the development of electronic braille keyboard devices which can aid braille literacy development among blind persons The venture model interface developed	Have done by using touch screen technology to test the interface and the development of interfaces using few keys to be deployed in situations where the user has a small device
S4	Ayad[20]	Multimodal, Combined With An Edutainment Approach	Efficiency, Effectiveness, User Satisfaction, Memorability, Learnability, Interface Preference	General		
S5	Barghash[21]	Think Aloud	Learnability, Ease of Use	Medical Officer		
S6	Darejeh& Singh [22]		Ease Of Use, Ease of Understanding, User Friendly, Learnability, Satisfaction	Less Literacy		An area that was not explored in this work is associated with the mental impairment class
S7	Gibbons, Lowry & Quinn [23]		Ease of Use, User Experience.			
S8	Hernandez [24]	Stress Measurement	Easy-to-Use, Effectiveness			
S9	Kirner, Cerquiera&Kirner[25]	AR game	Easy to Understand, Easy to Learn, Easy to Use.	Cognitive Rehabilitation	Have high potential to be applied in educational and cognitive rehabilitation applications, due to the specific potentiality provided by the augmented reality and the three-dimensional artefact features.	
S10	Grego-Nagel [26]		Usability, Affordability, Accessibility, Technical Support, Social Support, Emotion, Independence, Experience, Confidence.	Older Adults		
S11	Alharbe[27]	Multimodal Interaction Approach	Effectiveness, Efficiency, Interactivity, User Satisfaction	General		
S12	Kim et al. [28]	VUI development	Effective, Satisfaction	Dysarthria		
S13	Stoll et al. [29]		Ease of Use, Ease of			

			Learning, Quality of Support Information, Satisfaction, Stigma			
S14	Faett et al. [30]		User Satisfaction			
S15	Kirner&Kirner[31]		Usability (Ease of Understanding, Ease of Learning, Ease Of Use), Human Factors (Usable, Effective, Accepted By Users), Ergonomics (Safe, Efficient).	Cognitive Rehabilitation		
S16	Parmanto et al. [32]		Usefulness, Ease of Use, Effectiveness, Reliability, Satisfaction			
S17	Loannidi et al. [33]		Usability, Playability, Applicability			
S18	Karpova[34]		Accessibility, Appearance	Autism		
S19	Custodio[35]	Usability guidelines (Nielsen, 1994).	Easy to Use	Autism	Interface elements should be persistently visible. Future interface designs for Vidcoach should make the badge list more visible or prompt the user to visit the list once a badge is earned. The on-screen dialog can present a button for the user to admire their collection of badges immediately after one is collected. To take into account the gaps in engagement, an on-screen message can welcome back the user	Quantify the impact of vidcoach on the various types of users it can serve examine natural patterns of use and see if a system like vidcoach can change those patterns and what impact that change would have
S20	Øhrstrøm[36]		Accessibility, Flexible	Autism		
S21	Feenstra[37]		Navigation (Supportive/Creativity Site Content Interactivity Responsiveness Helpful Emotionally Fulling), Rewarding Fun	Autism		
S22	Khan, Tazir, Raza [38]		Ease of Use, Learnability, Feedback & Error, Appealing Interface	Autism		
S23	Oestreicher[39]	Robot Approach	Consistency, Learnability, Memorability	General		

3. Result

3.1. Usability Factors for Designing Mobile Application for Autistic Children

After a thorough review of literature, we selected 23 recent works that follow the usability factors to identify elements of the usability that are compatible to be adapted for designing mobile application for autistic children.

Based on the study, there are no specific usability guidelines that focus on the interface design [40]. There are six usability elements that have been identified which frequently have been used for designing mobile application for autistic children: easy to use, effectiveness, understandable, satisfaction, appearance, and efficiency. These usability factors have been used to cater the autistic children disabilities in using mobile applications.

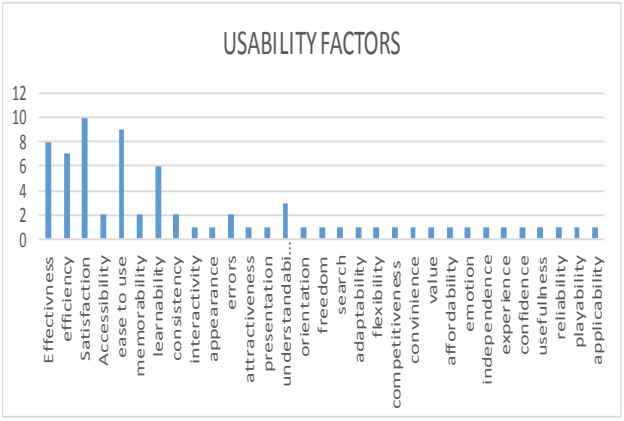


Fig. 2: Comparison of Usability Elements in Recent Works

Fig.2 summarised the literature review on the existing usability that has been used in previous studies for mobile application. There are thirty-one (31) elements that have been identified that meet the requirement of the designing interface for mobile application. The identified elements of usability that frequently have

been used are satisfaction, ease of use, effectiveness and efficiency respectively. They have come across seven to ten literatures reviews.

According to Darejeh[22], he believes that the autistic group required ease of use, understanding, learnability and satisfaction as their usability factors. Similarly, Kirner[31] in her studies suggested that the system that will be used by the autistic group must be easy to use, learnability and understandable. This is to ensure the usability factors meet the requirements of designing mobile application for the autistic group.

3.2. Usability Guideline of Interface Design for Mobile Application for Autistic Children

These are the general usability guidelines of interface design for mobile application for autistic children:

a) Objective – The purpose of usability guideline is to ensure interface design of mobile application applies usability-based quality. By implementing the six (6) elements, it will ensure that the quality development of mobile application meets the standard.
b) Scope – The scope of this guideline will cover the autistic children.
c) To develop the mobile application for autistic children, the usability guideline will include the following elements:

1. Effectiveness – This element refers to the accuracy and completeness of the task that has been performed. The interface of the mobile application must be able to display the desired output as expected by the users. According to Ravana[41], in order to increase the effectiveness of an application towards the autistic children, the button on the interface must be easily recognized by them for example by replace the button with the image representation. By adopting the following characteristics, the effectiveness of the application can be achieved. i). The size of the button in the interface must be large. ii) The amount of the words and features must be reduced. iii) The interface design able to allow the repetitive actions take place easily. iv) Image representation for the button.

Table 3: Result from Literature Review Analysis

Two (2) category of literature highlight in usability guideline for designing interface of mobile application for autism	
Study on Documentation Related with Mobile Application for autism	**Study on Documentation Related to Usability Guidelines and Elements**
Finding	
Usability	
a. Effectiveness b. Efficiency c. Satisfaction d. Ease of use e. Understandable f. Appearance	a. Effectiveness b. Efficiency c. Satisfaction d. Ease of use e. Learnability

2. Efficiency- The element refers to the resources that will use to increase the accuracy and completeness of the task. The interface must be able to improve the speed and accuracy to complete the task. It is also referred to give responses towards the action performed by users. Pavlov [42] in his study stated that to increase the efficiency towards the autistic people it is a need to have clear interface with mild colours and contrast between font and background, and no distraction elements which can clearly stand out the command button from the other elements. By adopting the following characteristics, the efficiency of the application can achieve. i) The interface must be able to reduce time in performing the task (clicking button) by setting appropriate symbols of a button. ii) The application needs to be able to update the latest version automatically. iii) Use contrast colour between background and fonts.

3. Satisfaction- This element refers to the user comfortable feeling towards the application. The system needs to meet the requirements of the user. In their study Nareena and Safeeullah[43] and Hussain [44], they stated that by having image representation in the application able to increase the satisfaction and able to increase learning success in the autistic children community. User satisfaction can be achieved based on the following characteristics: i) The interface must be able to provide feedback and reach the development team. ii) The interface must be easy in the eye of users. iii) Use image representation in navigate the user.

4. Ease of use- This element refers to the simplicity in performing tasks. By adopting the following characteristics, ease of use of the application can be achieved. As stated in Sitdhisanguan, et al. [45] studies which has been agreed by Aravindan [46], it shows that touch-based system able to provide ease of use and skills improvement due to its simplicity towards the autistic children. i) The interface shall be able to provide information easily and quickly. ii) The interface must be able to provide a single-clickable button (navigation). iii) The interface must have clear (colour) iconic button.

5. Understandable- This element refers to the clarity of icon in the application. According to Branch [47] which has been agreed by Ravana, et al. [41], to increase the understanding of the autistic children, pictures can be used to assist them. By adopting the following characteristics, understandable of the application can be achieved. i) The interface must be able to use easily understandable (or learnable) icons. ii) The interface needs to make items (icons) recognizable. iii) The interface must be able to provide catchy pictures or button.

6. Appearance- This element refers to the ability of the application to give cues to the user on how it behaves and how it interacts[48]. In Kamaruzaman, et al. [49] study, they stated that the appearance is important especially in term of position of the picture and words in attracting the autistic children to use the application and attention. Thus, in order to attract the autistic children attention, having a good appearance can be achieved based on the following characteristics: i) The interface must be able to have the appropriate colour of the font. ii) The interface must be able to have a suitable size of pictures or images and font. iii) The interface must be able to have suitable colour for the background

4. Discussion

User interface (UI) plays a vital role in terms of visibility, design and precision for depicting the exact amount of information for the intended users [9]. It is important to have a good interface design in order help in the learning process, reduce the complexity of software and enhance user satisfaction in performing the task. [50]. It is also important to have mobile applications that designed based on usability factor that able to cater autistic children's need especially in enhancing their communication skills, social skills and cognitive skills [51]. However, there are least number of mobile application that follow the guidelines that can cater the needs of the autistic children due to the lack of usability guidelines for mobile application and relatively unexplored and unproven [40, 52, 53]. Some researchers have conducted the studies on the existing usability guidelines and they agreed that the existing usability guidelines are insufficient in designing effective interface for mobile applications. This is due to peculiar features and dynamic application context in mobile[40][54] and it is also difficult to use; particularly in terms of user-interface design [44].Thus, it is a needs to have a good interface in developing a mobile application for autistic children that follow usability guideline.

The researchers believe that even minor decisions that have been made able to negatively or positively contribute to the application. Thus, it is a need to study the elements of a good interface design and to have usability guidelines in the designing process of the interface for mobile applications, which in this context is for autistic children. This is because autistic children are visual learners which they will show good response to visual interaction in learning process [38]. By having a good interface design for mobile

application, these autistic children able to enhance their disabilities in communication, social, and cognitive skills through mobile technology.

Usability, in general, is one of the vital concepts in Human-Computer Interaction (HCI) because it able to give impact in the making of a system easy to use and understand. There are many scholars gave their thought in defining the term of usability in the system design. Usability is originally derived from the word "user-friendly" [55] however, the term had gained a large group of vague and subjective intentions and accordingly the expression of "usability" was recommended to supplant this term [56]. Recently, the term of "usability" has been defined as the quality of use [57] which it can rather be measured as the result of interaction in a context that the resources, for example, time, cash or mental exertion that must be exhausted to accomplish the objectives (effectiveness) and the extent to which user finds the whole system worthy (satisfaction) [58].

In this study, the gap analysis has been identified and analysed on the compatibility of the usability elements of designing mobile application for autistic children. As for the result, there are six elements identified which are suitable for autistic children based on their capability to handle the system. The elements are effectiveness, efficiency, satisfaction, ease of use, understandable and appearance. All of these elements will be used to help in designing the mobile application for autistic children.

The guideline will be designed during the theoretical phase. This guideline will be based on the usability elements that have been extracted from the literature review analysis in TABLE 3. The literature review analysis conducted in order to obtain details of the elements. Nine papers have been used during the literature review analysis and frequent usability elements extracted.

It is important to know the usability factors that will be used especially when the users are the special needs; autism. This is to ensure that interface design meets the requirements. According to Custodio [35], he conducted a study on the impact of persuasive design on motivation and technology use. The persuasive design requirements showed potential to motivate participants. The usability factor that has been used in this study is easy to use in designing the system. This is the reason why it is a need to know the usability factors that required in the system. It is to help in designing the mobile application which able to enhance the autistic group skills.

5. Conclusion

In this study, we identified 23 papers that used usability elements in designing mobile application for autistic children. We arranged, categorized and collected the information obtained to provide an answer to the research question. The different types of methods have been assessed, usability factors used, as well as the contribution and limitation that have been assessed have been categorized. These categorization provide a guideline for further research related to usability guideline for designing mobile application user interface for autistic children.

In this study, we found that the usability elements that have been frequently used to design mobile application for autistic are satisfaction, where more studies have been used this elements in designing mobile application, followed by effectiveness, efficiency, ease of use, understandable and appearance. The understandable and appearance have been added due to their relevancy towards the characteristic of the autistic children. The main objective of performing this systematic literature review was to find useful information on the existing usability factors that frequently used by the practitioners or researcher (for mobile app design for autism).Based on the result obtained, we have selected assessment method by [16] and [14] to help classified the paper and identified the usability factors.

This study has helped us to analyse the method and usability factors used to design mobile application for autistic children. It also help us to select usability elements to develop guideline for designing mobile application user interface for autistic children. Our next steps are to finish the construct of our expert review questions and to carry out the experiments and evaluation sessions. We also plan to analysed and arranged the information obtained in this study, so that the usability guideline for designing mobile application user interface for autistic children can be developed.

Acknowledgement

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