Systematic Review On Usability Of Mobile Learning Applications for Children

Azham Hussain[1]*, Emmanuel O.C. Mkpojiogu[1] & Fa'alina Hassan[1]

[1]School of Computing, Universiti Utara Malaysia, 06010 Sintok, Malaysia.

*Corresponding author
azham.h@uum.edu.my

Abstract

The accelerated development of new technology, particularly on mobile application has increased teacher's responsibility as a learning facilitator. Mobile learning application is very useful in enriching the mobile learning experience of children. However, some applications fail to assist and increase children knowledge on the subject they studied. Moreover, some children are not interested in mobile applications due to other issues such as poor interfaces. In this paper, some previous studies on dimensions used to evaluate mobile learning applications were reviewed. The systematic literature review approach was employed to search previous papers and studies on usability dimension, particularly for mobile learning applications. The result showed that the top four usability dimensions are efficiency, effectiveness; learnability and user satisfaction. This study explored the current literatures on the subject matter and stimulates further studies that will lead to improved usability of mobile learning applications for children.

Keywords: Usability, Learning, Education, Mobile Application, Evaluation

1.0 BACKGROUND

Now is the era of mobile device where the mobile device is being considered as the most important technology. In the early 1970's was the computer era, followed by laptop era in the 2000's and now is the mobile device era. Almost everybody is expected to have at least a mobile device for use. Even a toddler as young as 3 years old will have and know how to use mobile devices. Many large organizations have converted or extended their computer-based applications to mobile-based applications because of the potentials that the mobile devices bring. So, in order to grab user attention to use these applications, the design of the mobile applications is very important as it influences and convinces users to use them [1] [11-14].

Mobile devices are increasingly becoming integrated into various aspects of our daily lives. One area is in the education sector, where mobile phones are being used as the educational platform and tool for teaching and learning. Mobile devices and services have the potential to improve learning and education. Therefore, the application of computer-based learning has gradually become unfit for use due to the rapid development of mobile technology, which means that all activities are carried out with the use of mobile devices. With the continuing development of mobile technology, the prices for mobile devices have lowered. This allows them to be available to the majority of people. In addition, usability has become a major quality indicator in software applications. From the user's perspective, the interface of software application is the most important component, because it is the primary

place of interaction with the software. Conversely, the definition of usability not only involves the process of interaction, but also the design of the interface. Changes to the design can be expensive, if the inspection activities and usability assessment were not carried out throughout the entire development process [11-14] [20].

Since the application for smart mobile phones is in high demand and competitions are getting higher in mobile application store markets, many developers tend to develop mobile applications faster. Testing is a very important aspect to ensure the application does not lack any usability aspect. The applications are tested on both emulator and mobile devices in order to understand their behavior on different platform.

Most teachers receive IT training by attending teacher training courses. Due to their weak IT background and the special needs in their work, the traditional lecture-based approach, which is adopted in many computer courses, are ineffective and boring. Education applications for mobile devices motivate and grab their attention while helping them focus on solving their problems, improve their memory, reading and writing. In addition to the traditional classroom context, the use of advanced technology in the learning process and evaluation through mobile learning test applications allow students to manage the use of time according to their needs for personalized experience [1][3-5] [7].

Mobile learning applications seem to be favored by children, because they can potentially accommodate a variety of features and sections that offer an interactive learning experience. It provides a stress free environment enhanced with friendly user interface design. The design and layout of the text can eliminate frustrations and confusion, while making information resources easier to take. In fact, mobile education applications encourage children to carry a larger amount of training. The interaction of children and learning through technology can increase their ability to map their minds [16].

This paper gives a brief idea about the relevant and appropriate usability dimensions and measurements for usability evaluation of mobile education applications for children. Systematic literature review (SLR), an approach used to revise a number of papers and find existing evidence that can be used to summarize the empirical evidence about an area of study and the benefits and limitations of a particular method [15] [27], was used in this study. In this study, this approach provides a template to identify current usability dimensions and measurement that are usually used in research. The purpose of this research is to identify relevant usability dimensions and measurement for evaluating the usability of mobile education applications for children.

1.1 Evaluating Usability

Usability is defined by the ISO as "the capability of a software product to be understood, learned, used, and attractive to the user, when used under specified conditions" [17]. The usability of applications in the learning environment are evaluated by using a more generic approach in the study of usability such as learnability, efficiency, memorability, user satisfaction, effectiveness, simplicity, performance and understanding[20,21]. Usability defines how easily children complete certain tasks, how fast their performance is and how many mistakes they make during the process [28]. These are measured through usability testing. The understanding and readability of the content and the ability to remember information and application function is part of a significant evaluation results that help in the modification of the applications [23].

Another approach to improving usability is to make the user interface or content adapt to the user. Making information personally valuable in a given context is one way of adapting to the user. The diversity of reasons for the use of mobile technologies in education makes it difficult to make any generalizations about requirements. Nevertheless, there are attempts to characterize these requirements, in relation to interface design and usability.

Usability is typically considered from the point of view of issues or problems encountered by users, but good usability essentially means that learning can proceed without obstacles and might even be enhanced by the availability of certain features. One of the key components of a successful and acceptable educational application is ease of use [21] [26]. Several high quality applications available in the market actually lose out because of their complexity, unattractiveness and confusing user interface. Thus, when designing a user interface for mobile phones, especially for education purposes, the user requirements of these devices should be considered [2] [24].

In fact, usability has been less extensively covered than the technological aspects of the mobile education application. Mobile technology can be successful as an educational platform only when the future research into the area of m-Learning includes fruitful discussion on all aspects of usability like: learnability, understandability, ease of use, effectiveness, and efficiency etc, of mobile applications [2] [25].

The main objective in this paper is to review the usability literatures on mobile learning applications for children. The paper is organized as follows: section 2 provides the methodology used for the study. The section includes the search strategy, selection of primary studies, extraction of data, and implementation of synthesis strategy, section 3 presents the general findings of systematic review, while section 4 concludes with the conclusion and future work.

2.0 METHODOLOGY

In order to achieve reliable results for this study, a systematic literature review (SLR) approach was used. This paper discusses the relevant and appropriate usability dimensions and measurements for mobile learning applications for children. This approach is applied by collecting and analyzing the previous researches that have been done by other researchers before. The study exposes significant dimensions and measurements to be used in evaluating mobile learning applications for children. In order to facilitate the process of the systematic review, the following were carried out: the definition of search strategy, the selection of primary studies, the extraction of data, and the implementation of synthesis strategy.

Today, computers have become one of the most important gadgets that people must have. With the mobile internet, human lifestyle has been changing greatly, as people can communicate with other people around the world easily and faster. A large amount of research is being conducted to explore the benefits of using Information and Communication Technology as a learning platform for individuals, especially children with learning difficulties [29].

The main focus of this paper is to evaluate the usability of mobile education applications with respect to how they affect the learning experience of children, as well as the consequences and benefits they offer to children. The mobile education applications were considered. They intersect computer technology and

mobile e-learning, and combine individualized learning with anytime and anywhere learning. With the explosive wave of the internet, children can get lessons, notes and tutorials just by using their hands, touching on screen and surf through the internet. Usability testing is an important task to ensure the applications fulfill customer needs and do not lack any usability aspect in any way [8-9] [15]. Testing is compulsory since the applications have a huge responsibility of meeting the user's needs. Testing is also needful, since the development of the applications is been done fast due to the high competition in the market.

2.1 Search Strategy

Many papers in this field of study were searched and only related and relevant papers were selected. In order to perform the search and selection of research studies, two processes were defined, namely, search process and study selection.

The search strategy was defined based on the scope, involvement, and outcome criteria, in order to carry out the search and selection of research studies. The terms of the search were chosen, taken into consideration the usability, learning, education and interference of the child's behavior. The basic search strings were defined after evaluating the different possible options for search terms.

a) Search Process: The search process was comprised of two phases: the primary search and the secondary search. The primary search was performed using fifty online databases that contained references for scientific articles and journals, conference proceedings and technical papers such as EdITLib, Emerald, Google Scholar, Academia, ACM, Springer and IEEE Xplore [18].

In the secondary search, a thorough review was performed for references and citations obtained during the primary search. In this case, the most relevant citations for the previously selected articles were determined [18].

b) Study Selection: A set of precise selection criteria (inclusive and exclusive) to select the most appropriate studies for the systematic review was defined. The inclusion of studies was determined by the following criterion [18]:

- Usability methods that have been applied to mobile education software development.
- Recommendations for the applications of usability methods in mobile education software development.
- Observations of user behaviors.
- Usability metrics and dimensions.
- Reviews or similar systematic mappings.

2.2 Selection of Primary Studies

This section describes the selected journal for this study. The total of 120 journals were reviewed based on the keywords "usability", "evaluation", "children" and "education". Only 50 out of 120 journals were selected for further review for the obtaining of guidelines for mobile application development.

Extraction of Data: The extraction of data process was mainly defined by the design of the data extraction forms that would precisely register the information obtained from the selected studies [15]. The content of the data extraction form included the following information which are (a) Paper title, (b) Author's name, (c) database engine that the papers were found.

Implementation of Synthesis Strategy: 120 journal papers from 7 databases were got. After the application of the inclusion and exclusion criteria to this body of studies, 45 of them were selected for the review process. Then, after performing the secondary search process, 5 additional studies were gotten, which totalled up to 50 papers for the review. The details about studies found during the primary search process is shown in Table 1.

Table 1 Total articles classified by its database.

Database	Found Articles	Duplicate Articles	Selected Articles
Google Scholar	42	33	7
IEEE Xplore	35	23	2
ACM	31	18	6
EdITLib	9	3	9
Emarald	1	0	0
Academia	1	0	0
Springer	1	0	1
Total	120	77	50

3.0 GENERAL FINDINGS ON THE SYSTEMATIC REVIEW

There are a few general findings that have been found in the research on usability testing [24-30]. These findings were derived from observation of a group of children in general view. The usability evaluating on mobile education applications for children has a few points to describe as follows: The first point is the hidden navigation. The screen space is very limited since mobile devices are small compared to computers [30]. Developer need to utilize the usage of the application in a very efficient way. So, the need for hidden navigation is very important so that the space can be saved for unnecessary usage. Since navigation is an integral part in the applications, the user need to be informed that the navigation panel is hidden whenever it is not used before they use the applications. If not, some users might not know how the navigation panel is functioning.

The second point is the clean interface. Clean interface in application design is proving to be a great trendsetter. Clean design means that the application interfaces are simplified rather than adapting too much style, or color etc. Despite being a simplified

design, it can still look stylish and perform efficiently. Besides saving the space of the screen, it also reduces the time to load the application. Users might become annoyed if the application takes a long time to load the interfaces that are rarely used by them.

The third point noticed is the application design that can connect to other objects. Since mobile phones are a device that always sticks with its owner, mobile devices can be controlled with the use of remote control. For example, Samsung recently released a washing machine that can be connected to Wi-Fi and controlled by smart phone application.

In addition, the studies reviewed also showed that usability evaluations are conducted during implementation phase only, and evaluation is often built as a description of the case study.

In this study, it is discovered that most researchers preferred efficiency, effectiveness, learnability and user satisfaction as best dimensions to be used. The mental and physical ability of children were also considered by researchers. The user interface of the application should therefore be very natural and intuitive to be used by all children (e.g. 6 to 10 years old children). The following four dimensions [15-22] with ten measurement criteria (sub-dimension) were found and selected from the study.

1) EFFICIENCY: Efficiency is a resources expended in relation to the accuracy and completeness with which users achieve goals. The general usability of mobile learning applications for children is a very crucial factor, as the children do not want to struggle with the applications, just because they are not interested in the user interface [6]. From an efficiency perspective, the less time spent managing resource access, the more time is available to capitalize on the value of those resources. There are unique demands for designing and administering mobile learning environment [10].Under efficiency dimension, three sub-dimensions were identified:

Compatibility: This dimension refers to compatible issues to users which might be varying depending on mobile device type and the children ability. Since nowadays smart phone has become important in our daily life, almost everyone has smart phone. Thus, children prefer to learn through mobile since it is convenient.

Loading time: This dimension refers to the time spent for the application to load in the mobile device and how much time taken for the application to respond to user. It should be as fast as possible to respond since the children will concentrate less if the respond time of the device is too long.

Accuracy: Accuracy measure refers to performance measure of application to complete a specific task, successfully and accurately within the allocated time. The application should return accurate results. By integrating these three dimensions, the efficiency of mobile learning application interfaces can be measured.

2) EFFECTIVENESS: Effectiveness is the accuracy and completeness with which users achieve specified goals. Effectiveness in most studies is measured by how many answers are correct. In order to measure the effectiveness of the application interface, these two sub dimensions were combined:

Presentation: This measure refers to how the buttons are presented. The buttons should be intuitive since the target users are children. Intuitiveness means that the user will know the meaning of the icons even without a description.

Navigation: Navigation menu should be in a logical structure where it makes sense for users in finding the right content.

3) LEARNABILITY: Learnability of a system implies that the system should be easy to learn so that the user can rapidly start getting work done with the system. Under learnability dimension, two sub-dimensions, which are simplicity and familiarity, were considered. Simplicity and familiarity can be integrated together to measure the degree of effort required for the user to learn the interface with a high level of satisfaction. Learnability is in some sense the most fundamental usability attribute[16]. The system should be easy to learn so that the user can rapidly start getting some work done with the system. Learnability is especially important for novice users.

Simplicity:This sub-dimension refers to the simplicity of the user interface. The interface should be simple as possible for users to perform tasks with minimal effort.

Familiarity: This sub-dimension measures whether the application interface has elements that are familiar to the user in order to enhance understanding.

4) USER SATISFACTION: Satisfaction is the freedom from discomfort, and positive attitudes towards the use of a product. User satisfaction measures the application interface in term of content, user guide, and attractiveness. Satisfaction is a multi-dimensional construct. Most of the study applied Likert scale to measure its directions and intensity (1= easy to use/high satisfaction, 5=difficult to use/low satisfaction). In addition to Likert scales used after each task, and in the post-test questionnaire, participants' comments are solicited. In addition to overall satisfaction and reaction, satisfaction are further examined in the areas of ease of use, organization of information, terminology, labeling, visual appearance, content, error correction, best features, and worst features.

Content: This sub-diemension measures whether the content of the applications meets user requirements. User satisfaction can be measured to determine whether the content has value to users.

User guide: This sub-diemension measures whether the interface provides user manual to help users during their use of the application. User guide can be in pop up message box instead of long manual documentation. A long manual documentation will not be really helpful since the target users are children.

Attractiveness: This sub-dimension measures whether the interface is attractive enough or not. The interface should be attractive as well as visually appealing to attract children to use it [23-30].

4.0 CONCLUSION

Without any doubt, mobile phones are the way of the future. Designers and developers of mobile learning applications for children need to consider the usability issues of mobile applications for learning in order to be accepted by children. Usability dimension is believed to be the important guideline for developers to ensure that users perform tasks in convenient ways. This research has presented selected usability dimensions which play vital roles in evaluating the usability of mobile learning applications for children. These dimensions are selected based on previous researches through systematic literature review. Related conferences and journals papers were reviewed carefully. The study reveals that little attention has been paid to researching the usability assessment in the area of mobile learning application design for children. The study also discovered that mobile learning applications for children must be easy to use, learnable, understandable, and attractive and should provide an enjoyable experience for the young users. It is important to meet usability needs for the mobile learning applications, since user interface plays the most important role for each individual interaction between the user and the Smart phone application. Future work will include the development of a conceptual framework for measuring the quality aspects of mobile learning application for children and a prototype application for smart phones using Java Language and Android Software Development Kit following the proposed framework as a guideline.

Acknowledgement

References

[1] Aderinoye, R.A., Ojokheta, K.O., Olojede, A.A. 2007. Integrating mobile learning into nomadic education programme in Nigeria: Issues and perspectives. The International Review of Research in Open and Distributed Learning, 8(2).

[2] Skiada, R., Soroniati, E., Gardeli, A., Zissis, D. 2013. EasyLexia: A Mobile Application for Children with Learning Difficulties. 5th Int'l Conf. on Software Development & Technologies for Enhancing Accessibility & Fighting Info-exclusion, (2013).

[3] Albalawi, R. 2013. Evaluating Tangible User Interface-based Mobile-learning System for Young Children.

[4] Ali, A., Alrasheedi, M.A.O. Fernando, L. 2014. A Study of the Interface Usability Issues of Mobile Learning Applications for Smart Phones from The User's Perspective. Int'l J. on Integrating Technology in Education (IJITE), 3(4) Dec.

[5] Alsugair, B.A., Hopkins, G., Brailsford, T., FitzGerald, E. 2011. Does mobile technology support peer learning for Key Stage 3 children?. 7th Int'l Conf. on Intelligent Environments.

[6] Alsumait, A., Al-Osaimi, A. 2009. Usability heuristics evaluation for child e-learning applications. In Proc. of the 11th ACM Int'l Conf. on Information Integration and Web-based Applications & Services, Dec: 425-430.

[7] Attewell, J., Savill-Smith, C. 2004. Mobile learning and social inclusion: focusing on learners and learning. In Learning with Mobile Devices, Research and Development Conf. (mLearn), Rome: 3-11.

[8] Aziz, N.A.A. 2013. Children's Interaction with Tablet Applications: Gestures and Interface Design. Int'l J. of Computer and Information Technology 2(3), May.

[9] Baber, C., Sharples, M., Vavoula, G., Glew, P. 2004. A learning space' model to examine the suitability of different technologies for mobile learning. Learning with mobile devices, 21.

[10] Caudill, J.G. 2007. The growth of m-learning and the growth of mobile computing: Parallel developments. The Int'l Review of Research in Open and Distributed Learning, 8(2).

[11] Chen, X., Ragonesi, C., Galloway, J.C., Agrawal, S.K. 2014. Design of a Robotic Mobility System with a Modular Haptic Feedback Approach to Promote Socialization in Children. IEEE Transactions on Haptics, 7(2), April-June.

[12] Csata, T. 2004. Evaluating non-functional requirements in mobile learning contents and multimedia educational software. Learning with mobile devices, 13.

[13] Dawabi, P., Wessner, M., Neuhold, E. 2004. Using mobile devices for the classroom of the future. Learning with mobile devices, 55.

[14] David, P., Hokyoung, R., Mark, C. 2007. A Design Requirements Framework for Mobile Learning Environments. J. of Computers, 2(4).

[15] Keele, S. 2007. Guidelines for performing systematic literature reviews in software engineering. Technical report, EBSE Technical Report EBSE-2007-01: 1-57.

[16] Nielsen, J. 1993. Usability Engineering. Boston MA. Acad. Press.

[17] ISO IEC 9126-1:2001. 2001. Software Engineering-Product Quality Part 1-Quality Model: 2

[18] Salvador, C., Nakasone, A., Antonio, J. A systematic Review of Usability Techniques in Agile Methodologies. IEEE

[19] Druin, A. 2009. Mobile Technology for Children Designing for Interaction and Learning. Morgan Kaufmann.

[20] Hussain, A., Mkpojiogu, E.O.C., Hussain, Z. 2015. Usability evaluation of a web-based health awareness portal on smart phone devices using ISO 9241-11 model. Jurnal Teknologi, 77 (4): 1-5.

[21] Hussain, A., Mkpojiogu, E.O.C. 2015. An application of ISO/IEC 25010 standard in the quality-in-use assessment of an online health awareness system. Jurnal Teknologi, 77 (5): 9-13.

[22] Hussain, A., Mkpojiogu, E.O.C. 2015. The effect of responsive web design on the user experience with laptop and smart phone devices. Jurnal Teknologi, 77 (4): 41-47.

[23] Thomas, S., Schott, G., Kambouri, M. 2004. Designing for learning or designing for fun? Setting usability guidelines for mobile educational games. Learning with mobile devices, 173.

[24] Wood, S., Romero, P. 2010. User-centred design for a mobile learning application. Proceedings of the 3rd

Mexican. Workshop on Human Computer Interaction(MexIHC'2010),1

[25] Zhang, R. 2009. Using Mobile Phones to Assist Children's Learning in Universeum.

[26] Edith, M.J.J., Eduardo, C.B., Eval, B.B.C. 2010. Tool for Experimenting with Concepts of Mobile Robotics as Applied to Children's Education. IEEE Transactions On Education, 53(1), Feb.

[27] Hanna, L., Risden, K., Alexander, K. 1997. Guidelines for usability testing with children. Interactions, *4*(5): 9-14.

[28] Muyinda, P.B., Mugisa, E., Lynch, K. 2007. M-learning: The educational use of mobile communication devices. Strengthening the Role of ICT in Development, 72.

[29] Kukulska-Hulme, A., Traxler, J. (Eds.). 2005. Mobile learning: A handbook for educators and trainers. Psychology Press.

[30] Parhizkar, B., Obeidy, W.A.K., Chowdhury, S.A., Gebril, Z.M., Ah Ngan, M.N., Lashkari, A.H. 2012. Android Mobile Augmented Reality Application Based On Different Learning Theories for Primary School Children, IEEE.