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Usability Testing Methods for Mobile Learning Applications

Priyanka Mathur[1]
[1]Research Scholar, Department of C S and IT, The IIS University, Jaipur, INDIA
priyankam2611@gmail.com

Swati V. Chande[2]
[2]Professor, Department of Computer Science, International School of Informatics and Management, Jaipur, INDIA
swatichande@rediffmail.com

Abstract: ***"The search for common ground in a divided market" is how Ben Feigin (2013) describes mobile application development. The reach of mobile devices has grown exponentially in the past decade, with it grew the requirement and subsequently the need of developing mobile applications. As mobile phones have become popular in the society and many people can afford the cost, the demand of mobility is extended to teaching and learning purposes says Leung (2003). To cope with frequent development of Mobile Learning Applications, engineers need a reusable and cost-effective environment for testing mobile applications. In the fleet of mobile applications being developed everyday it is imperative that an application is of high usability to the user otherwise the rate of acceptance for the application falls. To make sure of its acceptance it needs to be ensured that is application is of high usability for the end user. It necessitates that; the application needs to be tested for usability thoroughly. Usability testing is a type of testing done from an end-user's perspective to determine if the system is easily usable. It refers to evaluating the ease with which users can learn to use a product. But, usability techniques to be carried out are large in numbers, so it becomes difficult to study all of them and then to decide the most appropriate one to be used. It is therefore required that an extensive study for the identification of the most suitable and relevant usability testing method is carried out.***

This paper aims to identify the most preferred usability testing method which is recommended by software practitioners and testers for testing a Mobile Learning Application (m-LA). To find out the most preferred testing method evidence based approach is used, where the evidences of usability testing methods being used by researchers are congregated through systematic literature review.

1. Introduction

Mobile-Learning applications (m-LA) referrers to education delivered through mobile devices such as tablets, smartphones and e-readers. It is a unique educational method to complement the class/lecture scenarios learning through computers and mobile, and is fast gaining popularity. The development of mobile learning systems to assist student learning is ever since an area of interest (Chen et al (2013), Chen & Hsu (2008), Sung et al (2005) and Ketamo (2003)) and is also gaining fast momentum in India. There is a huge rise in the development of m-LA, a recent survey by T*echnavio (2016)* suggest that the per annum growth is Rs 4.7 billion in India. To make the learning application more approachable to the users it needs to be user friendly, and thus needs to be tested for

usability. Usability Testing according to Harrison et al (2013) in the light of mobile applications is evaluated in terms of four main attributes: effectiveness, efficiency, satisfaction and cognitive load. As shown in Figure 1 usability testing is done to make the applications convenient and practicable for use. The purpose of this this testing is to review the application user interface with the end users using the application. This is to ensure that the design (layout, buttons and color schemes, etc.) enables the application functions to be executed easily and intuitively. Although Systems may be built 100% in accordance with the specifications, yet they may be 'unusable' for the end-users.

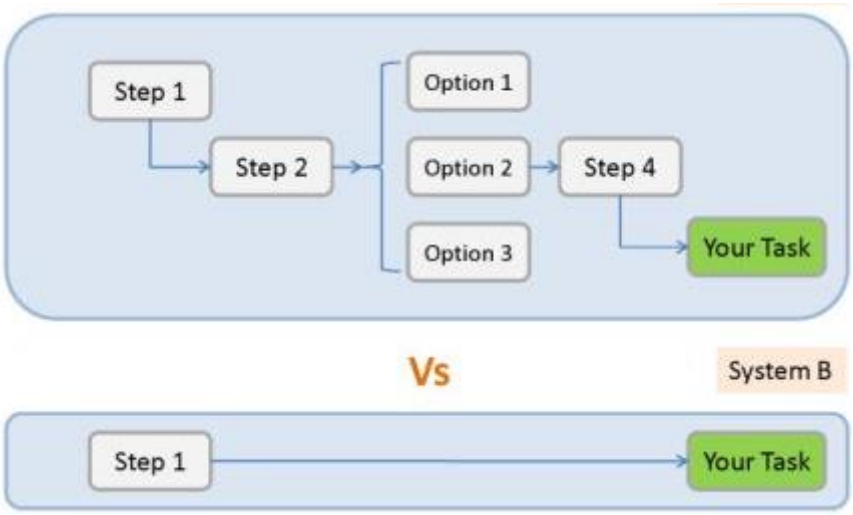

Figure 1: Usability Testing in Mobile Learning Applications

So to check for usability, it is required that applications are tested with appropriate techniques of Usability Testing. The number of Usability Testing methods is many reports Muccini et al. (2012). So to gather evidences for an appropriate method(s) suitable for m-LA a literature search was conducted to see the existing studies done in Usability Testing in m-LA.

2. Literature Review

As discussed by Muccinni et al (2012) mobile application testing techniques needs to be identified in particular due to the diversity of mobile platforms and different features of different mobile devices. So a literature search was done to identify the techniques used by researchers to test Mobile Learning Applications.

Hussain et al (2015) conducted an extensive usability testing on Mobile Learning Applications (m-LA) and suggests that the integration of agile development process and usability testing makes the

application more usable and user friendly. They further suggest that very few m-LA are tested for usability despite a hike in their development rate.

Alsumait and Al-Osaimi (2015) further reinforced that for a Mobile Learning Application [m-LA] to perform optimally, it must be scrutinized in terms of its usability like educational benefits and its ability to interact with users. This is important because e-learning and m-learning applications should satisfy some factors like effectiveness, satisfaction of interfaces and effectiveness. Dirin (2015) in his research proposed a mLUX (mobile Learning Usability and User Experience) framework for multitasking mLA. They suggest that efficiency in usability is a highly motivating force for the users to opt in for such applications. As Traxler (2005) had emphasized very early that mobile learning using handheld computers is a juvenile pedagogical tool; and it is developing rapidly. Mere technology is not enough, there is an obvious need to design these applications so that they are user-centered and have high usability.

A study by Oyomno et al (2013) tries to solve the usability issues with a different user perspective, they suggest usability studies be focused on the leitmotifs of effectiveness, efficiency, learnability, memorability, error-rate, and scope. Kronbauer et al (2012) found lack of approaches in the literature which suggest techniques to implement usability testing in mobile applications except for few methods like quantitative data (metrics), subjective evaluation (users' impressions) and context data.

3. Method

This section discusses the Systematic Literature Review (SLR) for Usability Testing in m-LA. In this study, our research methodology for a SLR was based on the guidelines laid by Kitchenham and Charters (2004). In order to gather the evidences the following stages were followed for systematic review:

- Formation of research questions,
- Definition of search strategy,
- Selection of primary studies,
- Extraction of data, and
- Results analysis.

3.1 Formation of research questions

This study aims to build a classification scheme of all the related evidences gathered by studying empirical studies of Mobile Learning Application testing through Usability Testing techniques. The study tries to identify the contributions made by various researchers through their studies on Usability Testing on m-LA reported till the current year.

To achieve this, the following research question (RQ) was specified: **RQ. Which of the existing Usability Methods (UM) are frequently applied for Mobile Learning Application development specifically?**

The RQ was framed to discover if the UMs have been specifically crafted for the Mobile Application field or they have been taken from already existing UMs and which of them are most favoured amongst the researchers for m-LA.

3.2 Definition of search strategy

In this SLR, both qualitative and quantitative empirical research studies have been included. The research studies have to be directly focussing on Usability Testing methods or approaches. To search for evidences we constructed a search string for which we adopted the approach recommended by Kitchenham and Charters (2007):

a) Search for keywords in Research Question(s) and then search for their synonyms and alternative keywords.
b) Use of Boolean AND/OR to incorporate alternate spellings and synonyms.
c) Use Boolean AND to join important terms together.

The search terms were taken from the research question (see Table 1). The terms “mobile application”, “testing”, and “challenges” represented the main terms. Additionally, we aggregated additional terms as synonyms such as “verification”, “fault”, “approach” and “limitation” to make the search broader and to ensure that we cover larger area.

The primary search process involved the use of standard online databases that index Computer Science and ICT related literature. These include: ACM Digital Library, IEEExplore, Scopus, ScienceDirect, SpringerLink and ProQuest.

# String	Search string
1	((mobile) AND (learning application OR learning software) AND (testing OR verification) AND (technique OR approach OR method))
2	((mobile) AND (learning application OR learning software) AND (testing OR verification) AND (technique OR approach OR method))
3	((("mobile learning application" OR "mobile learning software") AND (testing OR

	verification OR fault) AND (technique OR approach OR method)))
4	((("mobile learning application" OR "mobile learning applications" OR “mobile learning apps”) AND (testing OR verification) AND (technique OR approach OR method))))

Table 1: Search strings to identify Usability Methods

3.3 Selection of primary studies

These search strings were applied on all databases using advanced command search feature. Additionally to keep the results relevant with the changing environment in mobile applications the search years were restricted to 2010 to 2016. One study published in 2017was also included. The search process was constrained for studies related to computer science field only due to the fact that the term mobile is frequently used in many engineering disciplines.

The SLR was iterative in nature i.e. each paper passed through three steps of filtration:

a) We searched the database using search string, and the papers whose titles and abstracts were related to m-LA were included rest were filtered out.
b) In the second step the resulting studies from the first step were scrutinized on the basis of their complete text.
c) In the final phase all the related studies that were totally relevant with the RQ were grouped together and this constituted our primary data set.

This primary data set was then considered for result analysis. The first step shortlisted 218 studies and after the second step, 35 studies were found appropriate for finding the best suitable evidence for finding Usability Testing methods in Mobile Learning Applications . The methods identified are given in Table 2. The methods identified are Think Aloud, Remote Testing, Log file/Cognitive Walkthrough, Heuristic Evaluation, Guideline, Focus Group, Interview, Question, Expertise, Observation / Survey, Analytical Modeling and Simulation. These methods are further classified on the basis of classification given by Ivory and Hearst (2001).

3.4 Extraction of data

The aim of this step was to extract relevant data to answer our research question. For this purpose the relevant studies were sorted and data was inserted into tables, and frequencies of publications for each category were calculated.

Answer	Method	#Studies
Testing	Think Aloud	9
	Remote Testing	4
	Log file/	2
Inspection	Cognitive Walkthrough	7
	Heuristic Evaluation	10
	Guideline	2
Inquiry	Focus Group	2
	Interview	2
	Question	2
	Expertise	2
	Observation / Survey	3
Other	Analytical Modeling	1
	Simulation	1

Table 2 Usability Methods and their classification

From this primary data set some additional information (along with the usability testing methods used) that contributed to the research question was also fetched. Information like research approach of the study, study setting while testing (i.e. Field study or Lab Controlled experiments) settings was also analyzed. All the extracted data was collated on spread sheets and the frequencies of the publications was noted.

3.5 Results Analysis

The research question that was framed for the study was:

RQ. Which of the existing Usability Methods (UM) are frequently applied for Mobile Learning Application development specifically?

To answer this RQ, the studies included in this SLR were grouped and classified according to the classification scheme described by Ivory and Hearst (see Table 2). There were multiple occurrences of studies that suggested two usability methods to be used together. For such studies the frequency count was added in both methods. The main Usability Methods that are

recommended by researchers for testing mobile learning applications are Think Aloud (recommended by 9 researchers), Cognitive Walkthrough (recommended by 7 researchers) and Heuristic Evaluation (recommended by 10 researchers).

In the present work, as can be seen from Table 2 Heuristic Evaluation is by far the most widely used evaluation method which is implemented to perform Usability Testing. Another effective method is Think Aloud.

Researchers like M. E. Marwan et al.[2014], S. Al Roobaea et al.[2013], Abdoasslam Hatab M Katy [2016], Mohammed Rajab [2016], Ingrid Nascimento [2016], Medvidovic [2010], Marc Ericson C. et al.[2013] and a few more mentioned Cognitive Walkthrough (CW) as an effective UEM for Mobile Applications. Cognitive Walkthrough is when a usability expert simulates the actions of a novice user of the system. During this interaction, the inspector has to identify potential issues of usability.

Heuristic Evaluation is another method which is widely used by the researchers and practitioners as can be seen in representative studies conducted by Yong Gu Ji [2006], Roobaea AlRoobaea et al. [2013], Lin Chou Cheng [2016], Bettina Biel et al. [2010], Ingrid Nascimento, et al. [2016], Rodolfo Inostroza et al. [2010], Chul-Kang Yoo, Jung Yoon Kim [2015], Luis Rivero, et al. [2014], M.Fetaji, B.Fetaji [2011], Azham Bin Hussain [2015], Andrés Solano [2016], Rosa Yáñez Gómez et al.[2014] and many more. In Heuristic Evaluation/ Expertise / Heuristic Assessment a group of usability specialists/experts decide whether or not every dialogue part of the software follows established usability principles, it is referred to as "heuristics".

And a very few studies suggested Guideline Walkthrough/ Review as a desired UM under Inspection method.

The second most frequently referred UM class that is suitable for mobile applications is Testing, it encompassing UMs like Think Aloud, Remote Testing, Log file Analysis. Researchers like Fatih Nayebi et al.[2014], Rachel Harrison et al.[2013], Ashton King [2010], Abdoasslam Hatab M Katy [2016], Karin Leichtenstern[2014], Linda W.P. Peute et al.[2015], Tobie van Dyk [2013], proposed a UM for Mobile Application Development called the Think Aloud Method. User Testing – Thinking Aloud / Thinking Out Loud as suggested by the name this user testing involves the execution of the "thinking aloud

protocol". Users have to verbalize their thoughts while they interact with the software system. Supervisors should encourage end-users to express their opinions during the activity.

We believe that test engineers would find it difficult to choose among techniques available under the different categories of usability testing, based on our observation researchers suggest using Heuristic Evaluation or Think Aloud Method to be used imperatively while testing any m-LA.. These results will solve the problems of test engineers because several test methods and techniques exist with no clear road-map available for test engineers guiding them on which method or technique to choose while testing. We recommend future studies that can compare and confirm the literature results empirically.

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