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Usability Evaluation Techniques in Mobile Commerce Applications: A Systematic Review

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Abstract. Obviously, there are a number of literatures concerning the usability of mobile commerce (m-commerce) applications and related areas, but they do not adequately provide knowledge about usability techniques used in most of the empirical usability evaluation for m-commerce application. Therefore, this paper is aimed at producing the usability techniques frequently used in the aspect of usability evaluation for m-commerce applications. To achieve the stated objective, systematic literature review was employed. Sixty seven papers were downloaded in usability evaluation for m-commerce and related areas; twenty one most relevant studies were selected for review in order to extract the appropriate information. The results from the review shows that heuristic evaluation, formal test and think aloud methods are the most commonly used methods in m-commerce application in comparison to cognitive walkthrough and the informal test methods. Moreover, most of the studies applied control experiment (33.3% of the total studies); other studies that applied case study for usability evaluation are 14.28%. The results from this paper provide additional knowledge to the usability practitioners and research community for the current state and use of usability techniques in m-commerce application.

INTRODUCTION

Usability is one of the important things that should be taken into account by companies that offer software products. It increases sales because it makes products easier, better, and closer to the user's needs [1]. The products can be website, software application, tool, book, system, etc. According to Nielsen [2], five usability attributes should be available in any product: learnability (ease of learning), efficiency (efficient to use), memorability (ease to remember), errors (low error rate), and satisfaction (pleasant to use), (also, see [33-38]). Usability testing is not a single process in development of product; it is repeated multiple times in order to improve the quality of product [3]. There are different evaluation methods for usability. Some methods are based on real users, while others are based on opinion of experts. Selecting a method is dependent on several conditions such as time constraints, efficiency, and cost [2]. A study on the most frequent techniques used for a particular context of mobile application can help a lot of researchers and professionals [4]. Mobile commerce (m-commerce) refers to commercial transactions carried out using a diversity of mobile technology over a wireless telecommunication network setting. The mobile technologies mostly comprise of wireless application protocol (WAP), personal digital assistance, cellular phones, and now mobile with 4G network communication [5, 6]. Moreover, due to the stability in the development of mobile devices, m-commerce is progressively significant to many customers and businesses [7].

There are many challenges facing wireless communication networks and mobile devices such as slow network connection, small screen, and short battery life and so on. These challenges greatly affect the usability of m-commerce applications [7]. However, usability has become a central and superior pointer to mobile application design and quality. Looking at the user's perspective, the interface of mobile application is one of the most significant components, as it constitutes his/her main avenue of interaction with the application. For example, if a homepage of a company named "A" is difficult to read or does not provide support for different languages, then the customers will leave. This will provide an opportunity for competitors to gain more customers because company "A" is not giving enough attention to the usability of the interface of her homepage. Additionally, the definition of usability does not remain only on the interaction process, but also the issue of the design aspect of the interface is equally important [8-10]. Many literatures have attempted many different ways to find an answer for the application of usability methods in m-commerce applications. Systematic literature review can be used to know the effectiveness of such research works [11]. A number of literatures do exist concerning the usability of mobile applications, but they provide little knowledge about usability studies on m-commerce applications. Therefore, this

study will provide a synthesis of relevant and appropriate usability evaluation techniques used and the empirical studies available in m-commerce applications and in related areas through the use of systematic review approach. The essence of the study is to identify the boundary, weakness, and strength of the current research. In doing so, the need to address the issues raised will become imperative in future researches.

RELATED WORKS

The studies on human-computer interaction contain a number of contributions on usability techniques for mobile applications. Little literature does exist in the aspect usability techniques in m-commerce applications. The goals of usability techniques include: to enhance the interface design of an application or software products, capture usability problems and confirm the usability of the interfaces based on the criteria of usability measurements [12, 13]. Similarly, there are many approaches for evaluating the usability of an application or software product that have been practiced, such as usability testing and heuristic evaluation [8, 14]. Usability test is an approach in which a researcher invites users for a particular application prototype and ensures that the intended users of such application perform a specified task using a defined usability measurements approach. Whereas, heuristic evaluation is an approach of finding the actual usability problem of an application in a user interface design [15, 16] using a small number of usability evaluators to inspect the interface and justify its conformity with usability principles. The main objective of usability tests and heuristic techniques is to discover specific usability problems in an existing interface design. This discovery is either to enable improvement on the design of the interface, redesign the interface or to provide a benchmark. Furthermore, there are other usability evaluation approaches, which include: Cognitive Walkthrough [9, 17] and action analysis [7, 9]. Cognitive walkthrough is recognized as a supplementary instrument in usability engineering. The objective is to aid the design teams in evaluating early mock designs, easily and faster [18]. Furthermore, the term action analysis is a usability evaluation approach used to split the procedure of a task setup into uninterrupted activities to discover solutions to identified usability problems. Additionally, the prototype of an application or software depends absolutely on the designers and test objects [6]. As mentioned by Jeffries et al. [17], usability of a mobile application comprises of these techniques: heuristic evaluation, cognitive walkthrough, usability test, and application guidelines. Application guideline approach is the best of the four techniques at finding frequent and common problems. However, heuristic and usability testing techniques are more absolute compared to other techniques in the sense that they usually identify many and serious usability problems [17].

On the other hand, related work on how to conduct a systematic review of usability techniques in specific areas can be summarized in the following paragraphs. Salvador et al, [19] present a step by step systematic review about usability techniques in software-development methods when agile methodologies are used. The strategy for conducting a systematic review is based on selecting of search parameters carefully, writing of research questions, downloading primary articles, selecting related papers, extracting and summarizing information from them, and finally analyzing results. After implementing this strategy, 307 articles were downloaded, and from them 32 were selected for the systematic review. The results of analysis of data found three things: complementary evaluation techniques are the most common techniques in software-development methods when agile methodologies are used, most articles applied usability evaluation techniques only in the implementation stage, and lastly these techniques are mostly used as part of case studies [19]. Fernandez et al, [20] conducted a systematic review on usability evaluation methods for Web applications. The goal of the study is to identify the most effective method from a large number of presented papers in the field of web applications. The strategy for conducting a systematic review is similar to the one that was mentioned above. Using the strategy, a downloaded of 206 articles about usability techniques for web applications was made, and then only 18 related papers was chosen. The data from selected papers were extracted, summarized, and analyzed. The final conclusion of the systematic review was summarized in two points. First point shows that the quality and the number of empirical papers are low. This means there is a need for more researches on comparing usability evaluation techniques for web applications. Second point shows that there are several metrics to measure the performance of usability evaluation techniques. This means there is a need for standard metrics for the comparison of usability evaluation techniques [20].

Salazar et al., [21] performed a systematic review on usability heuristic methods for smart mobiles. The motivation behind the study is that smart mobiles are growing fast in the world causing an increase in the significance of shapes and interfaces for this type of mobiles. Another motivation is that many of the hypotheses about interaction of computers, which are known by many users, may not be valid for smart mobiles. The strategy for conducting a systematic review was based on analyzing the existing heuristic methods and mapping them to ten heuristics of Nielsen [2]. They also defined additional method proposed for smart mobiles. The findings of

systematic review are summarized in the following sentences. First, the study indicates that usability heuristics for smart mobiles are still in initial stage. Second, most of these methods are traditional, and they did not consider the characteristics of smart mobiles such as small-screen limitations and usage environment. Lastly, the study provides guidelines on the state of the art of heuristic techniques for evaluating interfaces of smart mobiles [21]. In addition, Insfran et al., [22] presented a systematic review on usability techniques for web applications' development. The motivation behind the study was that there are a large number of techniques and methods used to solve usability issues for web applications. Therefore, there was a need to find the most frequently used among them. Furthermore, in spite of the fact that there are many studies supporting usability techniques for development of Web applications, many designers and many organizations are not aware of them and do not know how to apply them. The goal of the systematic review was to identify what usability techniques have been applied by researchers to improve web development and how they were applied. In the systematic review, 410 articles were downloaded, but the selected related papers were only 51. The finding shows that 45% of the articles applied user testing as evaluation method for Web development. Furthermore, the results identified many research gaps in usability methods. For example, 80% of the methods are still applied in the implementation stage of the applications' life cycle development. In addition to that, 47% of the studies did not mention any validation for the usability methods used [22].

At second attempt, Insfran et al., [23] presented another systematic review on usability techniques for web applications development. The motivation behind the study was that there are several usability evaluation techniques that have been suggested to evaluate web development applications. However, most of these techniques still do not meet the requirements of users and companies. Furthermore, some companies have ignored these techniques of web usability, because they did not achieve much in spite of their high cost. Therefore, the goal of the study was to summarize and to analyze the existing knowledge regarding the usability evaluation techniques that have been proposed for web development applications over recent years. The strategy for conducting a systematic review is similar to the one used in first attempt. The result of the systematic review indicates that 39% of the articles reviewed used evaluation techniques that have been designed specifically for the Web applications. Furthermore, the result shows that the most frequently used technique was user testing. In addition to that, the study identifies some research gaps. For example, in almost 90% of the articles reviewed, usability evaluation was performed in the implementation stage of the web development process. Implementation stage is the most costly when performing any changes. Lastly, a list of recent usability evaluation techniques was also discussed that can be of help to researchers, designers and developers [23]. Aparna and Basheer [4] presented a systematic review on usability techniques for model based web applications. The motivation behind the study is that the numbers of websites are growing and they offer all types of services to the customers. Therefore, it is needful to define a set of usability guidelines to help website designers. The strategy for conducting a systematic review was based on evaluating usability using different evaluation techniques with focus on customer's satisfaction. To specify any complex website, a conceptual model is performed. The conceptual model is built based on heuristic methods in order to carry out expert reviews for different kinds of web applications. Furthermore, the study proposes different metrics for different levels of usability. These metrics that resulted were based on websites' classification taking into account the functions of these websites. In addition to the criteria, aspects that affect the evaluation process are listed. Therefore, the level of usability measured always depends on the type of websites being tested. Finally, the results of systematic review indicate that using conceptual model with evaluation techniques to predict and detect problems of usability was done as early as possible in the development stages [4].

Paz and Pow-Sang [24] presented a systematic review on present trends in usability evaluation techniques. The motivation behind the study was that there are many usability evaluation techniques available claiming the ability to solve issues and problems of usability. However, the scientific community is still discussing the best accepted usability method. Therefore, the goals of the study were to select the most frequent evaluation method over the recent years for a software application, and to identify current trends in this domain. The strategy for conducting the systematic review was based on the following steps. First, formulating the research questions carefully. Second, select the papers that present a state of art of usability methods by identifying search sentences. Third, specific databases are only considered when searching for primary papers. These databases are IEEE Xplore, Scopus, Science Direct, and ACM digital library. Fourth, each primary paper was reviewed to check if it is related to the systematic review or not. Lastly, the data from the selected papers were extracted according to the rules suggested by Keele [3]. The results of the systematic review indicate that the most frequently used method is usability testing, and these results depend on different categories of software interfaces. However, these results may be changed if the systematic review is conducted for a specific category of software [24]. From related works mentioned above, it can be noticed that there are many systematic reviews conducted in different categories. However, no one of the

conducted systematic reviews was on the state of art of usability evaluation techniques in mobile commerce domain. Therefore, this study will provide a contribution to help researchers and professionals in this particular domain.

SYSTEMATIC LITERATURE REVIEW

In order to identify the existing literature that deals with usability techniques in m-commerce applications, this study used systematic literature review approach to search for the relevant journals and conference proceedings on human-computer interaction and mobile-human computer interaction respectively. Furthermore, this systematic review was carried out based on the restrictions defined by Kitchenham [11]. Therefore, the anticipated activities in the systematic review include: planning the review as a first phase, conducting the review as a second phase and finally, result presentation. However, once the three phases have been achieved, the results of the analysis will then be presented.

Planning the Review

The aim is to collect important and appropriate information related to usability techniques in m-commerce applications. In this regard, the search and selection strategy is defined as primary and secondary search. The primary search was carried out using internet database for high-ranking journals and conference proceedings in the area of human-computer interaction and mobile-human computer interaction. The secondary search was carried out through the citation and references obtained in the course of primary searching. However, emphasis was given to recent studies ranging from the year 2005 to 2015. This will provide current issues on usability and its evaluation techniques for m-commerce application. Literatures on usability techniques of m-commerce are however, very limited. Table 1 below describes the selected journals and conference proceedings.

TABLE 1. Selected Journals and Conference Proceedings and Number of Papers

Journals	Conference Proceedings	Journal/ Conference Proceedings	No. of Paper	Journal/ Conference Proceedings	No. of Paper
International Journal of Human Computer Studies	International Conference on E-commerce Technology	IJHCS	2	ICET	1
International Journal of Computer Science and Engineering	Conference on Software Process and Product Management	IJCSE	3	CSPPM	2
ACM Computer Human Interaction	International Conference on Software and Computer Applications	IJEC	2	ICSCA	2
International Journal of Electronic Commerce	International Conference of Mobile Business	ACM Computer Human Interaction	5	ICMB	4

The selection of appropriate papers for both journals and conference proceedings centered mostly on the area of general concept of usability, usability design and usability evaluation techniques. However, the review procedure was centered on the keywords: usability in m-commerce applications, usability evaluation approach in m-commerce applications and usability testing techniques in m-commerce. Therefore, all the related and appropriate papers have been carefully selected for effective review and data extraction.

Conducting the Review

In this phase, the papers selected were downloaded and the abstract of each was carefully read in order to examine its relevancy to this study. Sixty seven papers were downloaded from both journals and conference proceeding. However, only relevant papers with significant contributions were selected for further reading, as such only twenty one papers was considered. Table 1 presents the number of papers selected according to journals and conference proceedings. Table 2 shows the list of selected papers.

TABLE 2. List of Selected Papers

Paper ID	Authors	Year	Paper ID	Authors	Year	Paper ID	Authors	Year
E1	Hassanein and Head [25]	2003	E8	Jooste, et al. [7]	2014	E15	Odeh and Adwan [18]	2009
E2	Moczarny, et al. [12]	2012	E9	Emmanuel, et al. [27]	2012	E16	Zarifopoulos and Economides [31]	2009
E3	Ahmad, et al. [25]	2011	E10	Alnanih, et al. [28]	2013	E17	Condos, et al.[10]	2002
E4	Barnes & Corbitt [16]	2003	E11	Lee and Benbasat [8]	2004	E18	Wu [32]	2012
E5	Jefferies, et al.[17]	1991	E12	Moczarny [5]	2011	E19	Singh and Wesson [15]	2009
E6	Chan, et al. [9]	2002a	E13	Wang, et al. [29]	2005	E20	Min, et al. [14]	2009
E7	Ravendran, et al. [6]	2012	E14	Venkatesh, et al. [30]	2003	E21	Tarasewich [13]	2003

RESULTS

After detail review of the selected papers, the results of the usability techniques of m-commerce applications and the empirical studies involved are presented accordingly. The next section of this paper presents results on the m-commerce usability techniques.

M-Commerce Usability Techniques and Empirical Studies

The selected papers were carefully reviewed and the results were generated. Obviously, the results revealed that usability inspection approach for m-commerce has 52.38%, and testing approach covered 47.61%. Therefore, this shows that the usability inspection technique have been used more frequently compared to testing technique. However, the usability inspection technique comprises of heuristic evaluation and cognitive walkthrough methods. Based on the review, the heuristic evaluation is used more than cognitive walkthrough from the percentage obtained. The testing technique in m-commerce comprises of think aloud, formal tests and informal tests. The result shows that formal usability test is used more based on the percentages obtained. Please, refer to Table 3 for the usability techniques and percentages of each based on the reviewed papers.

TABLE 3. Usability Techniques in M-Commerce and Empirical Studies

Usability Techniques in M-Commerce				Empirical Studies			
Technique	Method	Studies	Percent age	Evaluation approach	Studies	Percentage	Overall percentage
Inspection 52.38%	Heuristic evaluation	E3, E5, E4, E8, E11, E16, E19, E21	38.09%	Experiment	E2, E6, E12, E12, E14, E15, E18	33.33%	57.13%
	Cognitive walkthrough	E13, E14, E17	14.2%	Survey	E8, E20	9.52%	
Testing 47.61%	Think aloud	E15, E18, E20, E12	19.04%	Case Study	E7, E16, E9	14.28%	
	Formal test	E1,E2, E7, E10, E6	23.80				
	Informal test	E9	4.76%				

Furthermore, the results obtained from the review indicate that 57.13% of the selected studies are based on empirical studies, whereas 42.87% did not provide the precise usability methods they used for the empirical evaluation approach. Table 3 also presents empirical usability approach. In Table 3 above, 33.33% of the studies were carried out using experimentation approach, 9.52% studies used survey method and 14.28% of the studies used case study. Therefore, this revealed that majority of the studies performed control experiment approach for usability evaluation.

CONCLUSION

Relevant papers in the field of usability in m-commerce and related areas were selected through the application of systematic literature review. Sixty seven papers were downloaded, but twenty one papers were finally selected. All the selected papers were carefully read in order to obtain the expected results based on the objective of this study. Therefore, based on the analysis, the results indicate the following: There are five usability methods used for m-commerce applications as indicated in Table 3. Heuristic evaluation, formal test and think aloud methods are the most frequently used methods in m-commerce applications compared to cognitive walkthrough and informal test methods. Similarly, the results revealed that most of the studies applied control experiment (33.3% of the total studies), while 14.28% of the studies applied case study usability evaluation. The survey method obtained only 9.52% in terms of applicability for usability evaluation in m-commerce applications. Therefore, the results acquired in this study showed the existing state of the application of usability methods/technique in the domain of m-commerce applications. In addition, this research also identified some shortcomings on the application of usability in m-commerce and related areas. Moreover, 42.87 of the selected studies did not provide the specific usability methods used for the empirical evaluation approach. Most of the studies lack comprehensive framework to demonstrate the applicability of other usability methods in m-commerce domain such as survey and field study.

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