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Usability Evaluation of Mobile Game Applications: A Systematic Review

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Abstract— Mobile devices and mobile applications have proven significant advantages in their implementation. Among the advantages could be seen in their usability, in which users tasks have been made hugely simplified. In regard to that, this paper reports on a systematic review on usability evaluations on game applications for mobile environment. It presents the main concepts, factors and methodologies of usability evaluation for mobile application. Altogether, 21 studies have been selected for the review. In most studies, the usability phase is done after finishing the applications' implementation. Expert Review and Play testing Method is the most popular technique to evaluate mobile game.

Keywords--: Mobile Application, Usability Engineering, Usability Evaluation, Systematic Review.

I. INTRODUCTION

Recently, mobile phones have become very popular in people's daily life as well as in business. Statistics show that nearly 3.3 billion mobile connections exist worldwide and the number is increasing every day. Information Technology (IT) trends and purchasing policies indicate that individuals use their personal phone for work. Mobile business has become mainstream and it is predicted that there will be more than 1.3 billion mobile workers. This situation has caused mobile applications to emerge as corporate IT initiatives that need to support the organizational functions [1, 2].

In ensuring applications in mobile environment are usable, measuring usability is an essential task. Part of the aims of usability measure is to ensure the application is accurate, has sufficient speed, and that the application is safe for the users. In its' early deployment, the usability of an application was determined subjectively. Particularly, the process was not

well-defined. In such situation, the aspects for measurement were up to the researchers, which sounds very loose. However, at the same time, the usability measurement and the methods for analysis were being developed [3, 4].

Generally, usability refers to the capability of a product to be understood, learned, operated, and be attractive to users when used to achieve the determined goals in the specified environments effectively and efficiently. It is normally demonstrated through the interface. Since its' deployment, a number of usability guidelines and standards have been introduced to ensure software products could meet this quality. Those guidelines are however generic rules for designing and developing web and desktop applications. Meanwhile, usability guidelines for mobile applications are still lacking and have been relatively unexplored and unproven. Although several usability guidelines for mobile games have been discovered, they are isolated and disintegrated. This issue is critical as the existing usability guidelines are insufficient to design effective interface for mobile applications due to peculiar features and dynamic application context in mobile environment [2, 5].

The present paper conducts to review previous related studies and current measurement factors and methodologies for usability evaluation of mobile games through systematic literature review (SLR). The paper has organized as Section one introduction, section two describes the process of designing and performing the SLR, section three discusses the results and the details which obtained, and, finally, section four concludes the discussions in this paper and recommends for future enhancement.

II. SYSTEMATIC REVIEW

This section consists of a detailed discussion on the research questions, research strategy, and selection of related studies for analysis.

A. Research Questions

The following research questions have been investigated in order to achieve the aim of this paper, which is reviewing the usability evaluation for mobile games. They are as follows:

- What are the usability measurement factors for mobile games?
- What are the appropriate usability evaluation methodologies for mobile games?

B. Search Strategy

This study ensures that the SLR details the contents of high quality paper. It is observable through the strategy, in which it involved two phases; primary search and the secondary search. During the primary search, the famous online databases that contain scientific articles and journals, conference proceedings and technical papers, including Google's Scholar, Science Direct, Scopus, and IEEE Xplore were searched. Particularly, Google's Scholar was the main source for the primary search (as table 1 shows) . Meanwhile, the secondary search involved a thorough review of the references and citations obtained during the primary search. For that, this study applied the following basic search strings:

C1 (\usability") AND (\evaluation" OR \testing" OR \test")

C2 (\method" OR \technique" OR \process" OR \methodology" OR \approach")

C3 (\Mobile" OR \Phone" OR \Phones") AND (\Game" OR \Gaming")

Eventually, the complete string used in our search was:

C1 AND C2 AND C3

Table 1: Search Results

Database	C1 AND C2	C3	C1 and C2 and C3	Selected
Google Scholar	143	106	21	13
IEEE	37	24	17	5
Scopus	27	19	12	1
Science Direct	14	8	6	2
Total	221	157	56	21

The previous table has shown the result of search for every journals and papers database. This review has been searched in main four online databases. The result shows that, Google Scholar is a main reference for this paper with 13 papers and another 8 papers from other databases.

C. Study Selection

Having browsed in the online databases, and searched using the strings in Section 2.2, a set of 21 appropriate related works has been gathered. All papers are summarized in a table, in which the contents of the table (as seen in Table 2) include the following information: (a) Study title, (b) Author(s), (c) year of publication.

Table 2: Related studies

Title	Author	Year
A Usability Testing On jFakih Learning Games for Hearing Impairment Children	Azham Hussain, Norasyikin Abdul Mutalib, Azida Zainol	2014
From Playability to a Hierarchical Game Usability Model	Lennart Nacke	2009
Usability testing: some current practices and research questions	J.M. Christian Bastien	2010
Studies on Usability of Mobile Applications: Review	M. Fatih Adak, Nejat Yumusak	2013
Usability of mobile applications: literature review and rationale for a new usability model	Rachel Harrison, Derek Flood and David Duce	2013
Expert Review Method in Game Evaluations – Comparison of Two Playability Heuristic Sets	Hannu Korhonen, Janne Paavilainen and Hannamari Saarenpää	2009
Designing User Experience for Mobile Game-Based Learning	Norshuhada Shiratuddin and Syamsul Bahrin Zaibon	2011
The State Of The Art Of Mobile Application Usability Evaluation	Fatih Nayeibi, Jean-Marc Desharnais, and Alain Abran	2012
Usability Dimensions for	Rosnita	2013

Mobile Applications-A Review	Baharuddin, Dalbir Singh and Rozilawati Razali	
An Evaluation of a Mobile Game Concept for Lectures	Alf Inge Wang, Terje Øfsdahl and Ole Kristian Mørch-Storstein	2008
Comparison of Playtesting and Expert Review Methods in Mobile Game Evaluation	Hannu Korhonen	2010
Game Usability Heuristics (PLAY) For Evaluating and Designing Better Games: The Next Iteration	Heather Desurvire and Charlotte Wiberg	2009
Evaluating User Experience and Other Lies in Evaluating Games	Heather Desurvire and Charlotte Wiberg	2008
Context-Aware Mobile Role Playing Game for Learning – A Case of Canada and Taiwan	Chris Lu, Maiga Chang, Kinshuk, Echo Huang and Ching-Wen Chen	2014
Methods for Evaluating Gameplay Experience in a Serious Gaming Context	Lennart Nacke, Anders Drachenan and Stefan Göbel	2010
Comparing Two Playability Heuristic Sets with Expert Review Method :A Case Study of Mobile Game Evaluation	Janne Paavilainen, Hannu Korhonen, and Hannamari Saarenpää	2011
Critical review on video game evaluation heuristics: social games perspective	Janne Paavilainen	2010
Lessons from an Educational Game Usability Evaluation	G. T. Perry, C. C. Kulpa, E. T. Pinheiro, and M. L. Eichler	2012
Design factors of mobile game for increasing gamer's flow experience.	Chou, J.C.	2014
Enhancing Mobile Satisfaction through Integration of Usability and Flow	Chia-Liang Hung, Jerome Chih-Lung Chou & Chung	2012
Usability heuristics for networked multiplayer games	David Pinelle, Nelson Wong, Tadeusz Stach, Carl Gutwin	2008

III. RESULTS AND FINDING

The obtained results are classified based on the research questions, their possible answers, and the explanation about those answers. In accordance, the next subsections detail the results of each research question.

A. Usability Factors

Usability factors are various features that are used to measure how easy applications are in supporting users' tasks. Based on the standard ISO 9241, HCI handbooks, and existing usability studies related to mobile applications, the usability of mobile games could be affected by the following seven generic factors. In order to answer the first research question, those factors are explained below:

1. **Learnability:** this factor emphasizes on how easy users can accomplish a task in the first attempt and how quick users can improve their performance levels (i.e., ease-of-use) [5].
2. **Efficiency:** It concerns on the time users take to accomplish a task. The difference between efficiency and learnability is that before efficiency is measured, users should have already experienced using the game [4, 6].
3. **Memorability:** In this factor, the level of ease with which users can recall on the way to play the game after discontinuing its use for some time is measured. The main idea is to measure how well users can re-establish the skill of using the game [6].
4. **Errors:** Errors can be measured by counting the number of mistakes that users make while playing the designed mobile game, the severity levels of mistakes, and how easy users can recover from them [1].
5. **User satisfaction:** It reflects the attitude of users towards in playing the designed mobile game and also the measure of users' satisfaction level on that mobile game.
6. **Simplicity:** It explains the degree of comfort with which users find a way to accomplish tasks. This factor has been frequently used to assess the quality of menu structures as well as navigation design in mobile applications [7].
7. **Comprehensibility:** Sometimes it is used interchangeably with the term readability. It measures on how easy users can understand the contents of the designed mobile game. Because current mobile games primarily deal with textual information, the presentation

of information has significant effect on users' understanding of the content [2, 7].

B. Usability Evaluation Method

There are two main methodologies applied in this study, namely user testing and expert review. Every method has certain advantages and disadvantages, in which this study takes the advantages into consideration by eliminating the possibilities of the disadvantages [8]. It has been a norm that mobile devices and game change very quickly. Accordingly, the techniques for measuring usability involve alterations when necessary, without compromising the rigorous factors in ensuring the process maintains scientific and systematic [9].

- Expert Review

Two experts in playability involved in the expert review session, which followed the recommended procedures. Those experts were selected based on their expertise in evaluating mobile games and software productivity. Particularly, both experts play different mobile games regularly, which enrich their experience when combined [10]. Additionally, they are also very familiar with the playability heuristics, which are specifically designed for evaluating mobile games [11]. On top of that, they have not involved in any sense with the development team of the game in this study, and they did not have any previous experience with the game developed in this study prior to the evaluation session. This provides a realistic context for them, and it resembles the situation that players will face when they get the designed game on their device for the first time.

In the procedure, both experts were instructed to explore the game (to get familiar with the user interface) and to try to complete as many levels as they could during the evaluation session. The instructions did not include tasks or scenarios that the experts should follow, but they were free to explore the game as they liked [12, 13].

Each evaluation session was timed commencing from the moment the experts launched the game for the first time. In the session, first, the experts examined the game menu and the general settings in the game. Then, they walked through the first level that serves as the tutorial for the game. During the walkthrough, the identified playability problems were written down briefly and the violated heuristic was assigned. The purpose of this is to minimize the experts' paper work, because it would otherwise disturb the experts' gaming experience. However, without recording the impressions, valued information may decay if not recorded immediately.

During the evaluation session, the experts focused thoroughly on both game usability and gameplay issues of the game. Sometimes the experts were observed playing some levels several times before they could really figure out their mind, which was very dynamic. This study was happy with the session because their active participation enabled them to explore the possibilities of the game and try out different

strategies and playing styles [12, 14], which eventually enrich their discoveries.

As a result, the evaluation session continued until the time required for finding new playability issues increased dramatically. This was based on the experts' own judgment and request. After that, the experts walked through the identified playability problems one by one. Simultaneously, the experts discussed on their findings. Then, the identified playability problems were clarified and all duplications were removed from the combined list [15].

Finally, the identified playability problems were assigned with a violated heuristic and severity. The experts documented the recommendations to fix the playability problems in the final step of the evaluation.

Altogether, the expert review session took approximately 3-4 hours for the accomplishment of the evaluation of the game, discussion between the experts, and documenting the findings. Meanwhile, the time for playing the game was approximately one hour. Although the experts did not finish the whole game, they managed to complete the first eight levels.

- Play testing Method

In complementing the expert review, a user testing session was conducted. Altogether, six experienced mobile phone users who have played mobile games to some extent (one female) were employed into the test, which was help in a usability laboratory. The average age of the users is 30 years, ranging between 26 and 35. In the testing, one participant played the game at a time [15, 16]. In this study, the procedure of the user testing followed the normal standard procedure. In the beginning, every player was briefed by this study on the technique to think aloud during the session and their background information was collected. After that, the player was allowed to start playing the game [17, 18]. This study observed the game session, more importantly on the way the player played the game. When necessary, this study asked questions to the user in the play. This study employed an assistant to make notes of the game session. Altogether, the session lasted between 60 and 90 minutes, consisting of the briefing, playing the game, and an interview at the end. The time for playing the game was approximately 60 minutes, and the difference in the total time was caused by the length of the interview which consisted of open-ended questions [12, 18].

Although the user testing in this study is similar to other standard user testing, there is one significant difference. Obviously, instead of using a set of specific or predefined tasks, the users in this study were instructed with a single open ended, addressed in the following:

"Play the game as you would play it on your own. I will ask you questions and tell you when to stop."

This study adapts the method based on the evaluations at Microsoft Games User-Testing Group. Technically, while the open-ended task does not specify any command to the players to perform or achieve any specific things in particular, or to play the game in any specified way, it allows this study to observe whether the players are able to understand the goals and other aspects in the game. Hence, this turns the evaluation session into a realistic experience, similar to those when experts are playing the game [19].

IV. CONCLUSION AND FUTURE WORK

In this study, 21 studies on usability evaluation of mobile applications were investigated. Having gone through the procedures, outstanding results have been obtained. Accordingly, the “What are the main factors of usability measurement for mobile game?” question has been answered based on the references. Also, this paper has listed all the factors of measurement of usability evaluation for games. Besides, this paper also explains every factor briefly. In a nutshell, the results obtained in this study agree with the previous studies who have proven that efficiency, effectiveness, and learnability are the main factors of usability measurement for mobile games.

On the other hand, the second research question, which is “What are the methodologies of usability evaluation for mobile game?” is also answered based on the previous studies. Expert review and user testing are the main methodologies in evaluating the usability of mobile game. The procedures of both are explained in detail in this paper. In the end, it was found that both expert review and user testing have discovered the most serious playability problems from the user interface. For the future work, the studies will be investigating for combining both of mobile game evaluation which are expert review and play testing methods to overcome disadvantages of every method and improve the usability testing for mobile game. As well as, using another usability testing methods for evaluate the mobile game such as qualitative and quantitative methods.

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