

Heuristics Evaluation Aspects for Mobile Game Based Learning

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Abstract: *As the use of mobile game based learning are increasing, it is essential to establish an evaluation tool as one of the important and crucial phases during development process. A comprehensive evaluation tool can help game developer to ensure the game's contribution to the learning process, as well as user's enjoyment. Usability heuristics method is a commonly used tool to evaluate game since this method can provide some benefits such as cheap, fast, easy to use, and can be done in early stage of designing the interface of a system. Usability heuristics is basically conducted by some usability experts, who assess the user interface of a system using a set of usability principles. However, most of the existing heuristics evaluations do not cover all aspects of MGBL in details, which is important to facilitate the developer to assess MGBL properly. In view of this, this paper presents a literature review on existing heuristics evaluation related to MGBL. It involves five different studies by other researchers. Later, this paper focuses on proposing heuristics that influence both game design and pedagogical aspects in evaluating MGBL. The results show five heuristics aspects that can be used to evaluate MGBL, such as Game Play, Game Usability, Mobility, Pedagogical, and Content.*

Keywords: *Heuristics evaluation; usability heuristics; mobile game-based learning*

I. INTRODUCTION

A mobile game based learning (MGBL) can be defined as a mobile game application that emphasizes on learning. It is used by various organizations and fields to bring fun and education in one form of edutainment. Increase learning encouragement, involve in knowledge acceptance, and enhance effectiveness of learning activities are the main objectives of MGBL [1]. Until now, MGBL has been used as an informal supporting tool to deliver learning materials. Research indicates that MGBL can help to motivate and encourage children to practice healthy and good habits [2]. Since mobile games for learning can bring a lot of advantages to both teacher and learner, it becomes a well-known booster to increase learning motivation [3]. Even though this technology cannot replace the formal education, but it is believed that it can provide a tremendous effect on education [4]. To ensure that mobile games for learning really increase the quality of learning, it is important to study the method evaluating this type of ICT applications. Hence, this research concentrates on the heuristics evaluation on MGBL, since MGBL should be evaluated accurately in order to assess whether MGBL can effectively help to achieve the learning objectives.

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In the further section, the scenario of problem related to this study will be elaborated.

It has been discussed previously that the acceptance of mobile game technologies as a learning medium has encouraged researchers and developers to study and generate more suitable tools for education [4]. Some researchers try to assign mobile game learning application as a tool kit, which helps teacher and students to learn about certain subject. Although this instrument can improve students' motivation and trigger social interaction, it can only be used as complement of formal learning system, not replace it [5]. It has a role as informal learning practice.

The success key of MGBL is not based on the sophistication of technology used, but through its impact on helping the user to obtain knowledge from the games. In order to achieve this success, an appropriate method is needed to assist developers in producing an effective and efficient MGBL. Many researchers have studied and proposed different methods of developing game based learning application [1, 6, 7].

In addition to the development method, evaluation method is one of the important and crucial phases during MGBL development process. Mohamed and Jaafar [8] state that comprehensive evaluation method is needed to ensure game's contribution to the learning process and user's enjoyment. It is necessary to verify this learning approach to provide the learners with a suitable learning environment [22]. Evaluation process can also be an assessment of usability (such as effectiveness, efficiency, and satisfaction), playability, and learning effect. Moreover, specific evaluation of a learning tool is required to examine whether the learning tool is effective and can give positive impact to the users [9, 10, 11].

Various researchers have proposed many evaluation methods of game. Most of them were evaluating the usability and playability of the game [8, 12, 13, 14]. They used lists of heuristics as guidelines to assess the game usability by some experts. Omar and Jaafar [15] and Hub and Capkova [16] consider this technique, Heuristic Evaluation (HE), as a "cheap", "fast", and "easy to use" technique, since it involves a small group of experts who examine an interface using a list of heuristics in early stage of game development process. They also believe that HE has the ability to rapidly find more significant usability problems, compare to other evaluation methods such as user testing. It seems that by discovering these problems earlier, developers can avoid more costly subsequent usability errors and high cost of re-design.

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There are only a few that focus on evaluating the learning process. It is important to ensure that education tool, including MGBL, can improve the quality of learning. It is supported by Omar & Jaafar [8] that a comprehensive evaluation method can help to ensure both game's contribution to the learning process, as well as user's enjoyment. However, there is limited of MGBL heuristics that can be used to evaluate and assesses learning of the users.

This paper is organized as followed: Section 1 provides the background of this study; Section 2 elaborates the concept of game usability and heuristics evaluation, as well as illustrates some existing heuristics evaluations related to Mobile Game Based Learning; Section 3 presents heuristics aspects for evaluating Mobile Game Based Learning; Last section of this paper concludes and provides future directions of this review.

II. GAME USABILITY AND HEURISTICS EVALUATION

Until recently, the most known evaluation technique used to evaluate MGBL is Usability Evaluation. This technique uses usability heuristics to be the guideline to assess the game. However, this evaluation technique can only be employed to evaluate the user interface of the game. This section presents reviews about usability evaluation and evaluations have been done using usability heuristics.

Usability evaluation

The ISO 9241-11 defines usability as “extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”. While Nielsen [17] proposes five usability attributes that need to be considered, such as:

- i. Learn ability: easy to learn, user can quickly perform their tasks.
- ii. Efficiency: easy to use, after user tried out and understand the system, productivity can be improved.
- iii. Memorability: easy to remember, user can automatically perform their tasks after some time of not using the system, with no learning needed.

iv. Errors: lack of errors, users can easily overcome the difficulty if error happens.

v. Satisfaction: pleasant to use, users like it.

On the other hand, Quesenbery [18] suggests five dimensions of usability. It is crucial to keep these dimensions in balance to avoid negative impact on final design. These five dimensions are:

i. Effective: the completeness and accuracy to achieve users' goals.

ii. Efficient: time required to complete the tasks.

iii. Engaging: how pleasant and satisfy to use the system.

iv. Error tolerant: prevent errors and provides errors recovery.

v. Easy to learn: easy to learn and easy to understand.

The intention of performing usability evaluation is always to inform the UID and to improve it at all stages of design life cycle. It is the best way to ensure whether the or not the system, through user interface, meets the usability requirements. Different types of usability evaluation may be carried out at different design staged for different reasons.

There are two types of evaluation based on the contribution to the system [18]. The first one is called diagnosis evaluation, which is carried out by looking for as many problems as possible that may occur, predicting the usability of the system, or assessing how well the UI meets the users' needs. This type of evaluation is usually done by using paper-based prototype in the early stage of design life cycle. The result of this evaluation may bring feedback to the user interface design, so that it can be improved to reduce the problems that may occur later on.

The other one is measurement evaluation, that measures the performance of the nearly completed system and ensures that it meets the usability requirements. This evaluation may be undertaken in later stage of design life cycle. However, the findings obtained from this evaluation may not be used to improve the UI design, but for the next version of the system.

According to Stone et al. [18] there are two main techniques of usability evaluation, such as user observations and usability inspections. Figure 1 represents the variations of the two main techniques of usability evaluations.

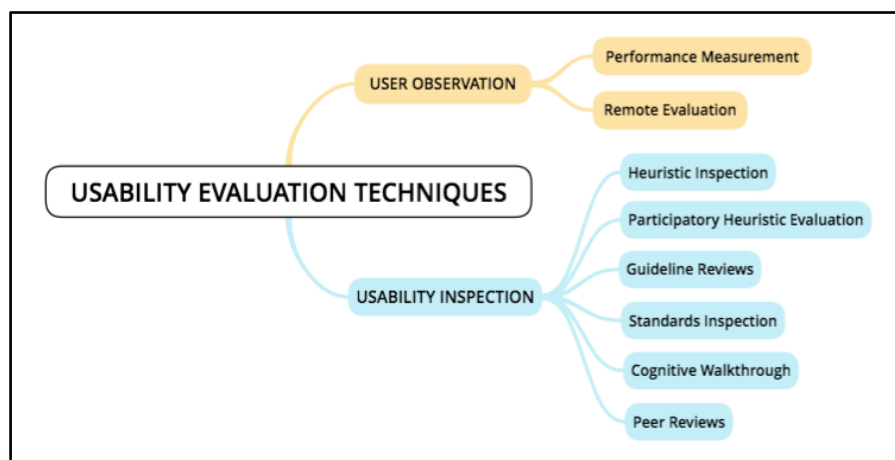


Fig. 1 Usability Evaluation Techniques [18]

Heuristics Evaluations for MGBL

Many studies have been done in developing usability heuristics evaluation. Usability heuristics is basically a usability principles list used to assess the user interface of a system, and conducted by some usability experts [19]. This usability heuristics method is one kind of informal inspection used to find usability problems that might appear when a user interact with an interface. There are some benefits of conducting usability heuristics method, such as cheap, fast, easy to use, and can be done in early stage of designing the interface of a system [15]. On the other hand, Hub and Capkova[16] claimed that combining both usability heuristics method and user testing can give a better and wider range of usability problems in a user interface design.

However, Desurvire, Caplan, and Toth[12] stated that it is important to focus not only on the user interface, but other

additional features of game experience are also needed to be evaluated. They suggested 43 heuristics that fall into four categories, such as: game play consists of set of problems and challenges that need to be solve by the user; game story contains plots and characters inside the game; game mechanics include the programming that provides interaction between user and environment; and game usability covers the interface and other elements used by user to interact with the game.

This section discusses five sets of heuristics evaluation proposed by Korhonen and Koivisto [13]; Ang, Avni, and Zaphiris [20]; Omar and Jaafar [15]; Zaibon and Shiratuddin[14]; and Soomro, Fatimah, Ahmad, and Sulaiman [21]. Table 1 shows comparison of some other heuristics evaluations that related to MGBL.

Table. 1 Summary matrix of Heuristics Evaluations related to Mobile Game based Learning

Authors	Heuristic Aspects										
	Game Interface/ Usability	Game Play	Game Rules	Game Narrative	Pedagogical	Content	Social Interactivity Function	Multi-media	Mobility	Multip-layer	Description
Korhonen and Koivisto (2006)	✓	✓							✓		Mobile Games
Ang, Avni, and Zaphiris (2008)	✓	✓	✓	✓	✓		✓				Computer Game based Learning
Omar and Jaafar (2010)	✓	✓			✓	✓		✓			Educational Computer Games
Zaibon and Shiratuddin (2010)	✓	✓				✓			✓		Mobile Game based Learning
Soomro, Fatimah, Ahmad, and Sulaiman (2012)	✓	✓							✓	✓	Mobile Games
Total authors that propose the component	5	5	1	1	2	2	1	1	3	1	

Playability Heuristics for Mobile Games

Korhonen and Koivisto[13] introduce playability heuristics for mobile games, that consist of three core modules such as game usability, mobility, and game play. Game usability addresses the game control and interface which facilitates the interaction between user and game. Mobility deals with issues and concerns regarding mobility of the game. Whereas, game play covers game mechanics and game story. From their findings, it indicated that game usability and mobility could help to identify problems easily. However, the playability problems were more difficult to find.

Heuristic Evaluation for Computer Game based Learning

Ang, Avni, and Zaphiris[20] establish a set of guidelines for the evaluation of computer game based learning, based on literature of computer games and learning theories. This set of 34 heuristics is classified into six categories: play, interface, rules, narratives, social aspects, and learn ability. Four categories are based on the typology of games they developed before, such as: play, rules, narratives, and social aspects. The other two categories focus on educational games, such as interface and learn ability.

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However, the validity of their guidelines should be enhanced to ensure its effectiveness.

Playability Heuristics for Educational Game

Omar and Jaafar[15] developed Playability Heuristics for Educational Game (PHEG) to evaluate the interface of educational games. They provide 42 heuristics that are fallen into 5 categories, such as interface, educational/pedagogical, content, multimedia, and playability. Later, they propose an online tool, called AHP_ HeGES, to help experts from various background areas to evaluate educational games [8].

Heuristics Evaluation Strategy for Mobile Game-based Learning

Zaibon and Shiratuddin[14] propose heuristics evaluation strategy for mobile game-based learning, that adapted from previous studies [13] and added a new component that covers learning content. Their heuristics evaluation strategy consists of 27 heuristics that are categorized into four different components, such as game usability, mobility, game play, and learning content.

Heuristics for Mobile Games

Soomro, Ahmad, and Sulaiman [21] claim that heuristics proposed by Korhonen and Koivisto[13] could not identified some of the mobile games problems. They propose 10 new heuristics to identify the playability problems of mobile games. Those heuristics are described in the Table 2.

Table. 2 Heuristics for Mobile Games

Game play	
1	The player able to save the game anytime
2	Game objectives are moderate (not to easy-nor to difficult)
Usability	
3	Player able to skip movies & images (non-playable)
4	Game allow customization
Mobility	
5	Game can handle interruptions (internal)
6	Player able to pause the game anytime
Multiplayer	
7	Multiplayer sessions can be easily created
8	Game sessions can be saved and restored in loss of connectivity
9	Game supports multiple connectivity medium
10	Game supports multiple ways of communications (voice & text)

III. HEURISTICS ASPECTS FOR EVALUATING MGBL

Based upon the study of the above evaluations, essential heuristics to be considered in evaluating MGBL have been identified. These heuristics aspects are chosen based on the summary matrix in Table 1, which are proposed by at least two authors.

In this section, the details heuristics are classified into five aspects, that cover both game design and pedagogical features. Those five aspects are discussed below.

Game Play Aspects

The game play covers game mechanics and game story as depicted in Table 3.

Table. 3 Game Play Aspect

H1. Game Play		
Guideline		Evidence
H1.1	The game provides clear goals or supports player created	[13], [14]
H1.2	The player sees the progress in the game and can compare the results	[13], [15]
H1.3	The players are rewarded and rewards are meaningful	[13], [14], [20]
H1.4	The player is in control	[13], [14], [15], [20]
H1.5	Challenge, strategy, and pace are in balance	[13], [14], [15]
H1.6	The first-time experience is encouraging	[13], [14], [20]
H1.7	The game story supports the game play and is meaningful	[13], [14]
H1.8	There are no repetitive or boring tasks	[13], [14], [20]
H1.9	The game does not stagnate	[13], [14], [20]
H1.10	The game is consistent	[13], [14]
H1.11	Challenge is adequate - not too easy and not too difficult	[15], [21]
H1.12	Challenge provided are up to the users standard/level	[15], [20]
H1.13	The player able to save the game anytime	[21]

Game Usability Aspects

Game usability addresses the game control and interface which facilitates the interaction between user and game (refer to Table 4).

Table. 4 Game Usability Aspect

H2. Game Usability		
Guideline		Evidence
H2.1	Everything the player needs should be accessible through the Graphical User Interface (GUI)	[20]
H2.2	The game interface should look pleasing, graphic design should be simple, easy to navigate, consistent in look, and varied in game play	[13], [14], [15], [20]
H2.3	The most important information should be located in the most noticeable location in the screen	[13], [14], [20]
H2.4	Audio-visual representation supports the game	[13], [14]
H2.5	Navigation is consistent, logical, and minimalist	[13], [14], [15], [20]
H2.6	Control keys are consistent and follow standard conventions	[13], [14], [15]
H2.7	Game controls are convenient and flexible	[13], [14]
H2.8	The game should provide feedback on the player's action or relevant to the problem/task	[13], [14], [20]
H2.9	The game contains help	[13], [14]

Mobility Aspects

Mobility deals with issues and concerns regarding mobile features of the game (Table 5).

Table. 5 Heuristics for Mobile Games

H3. Mobility		
Guideline		Evidence
H3.1	The game and play sessions can be started quickly	[13], [14]
H3.2	The game accommodates with the surroundings	[13], [14]
H3.3	Interruptions are handled reasonably	[13], [14], [21]
H3.4	The player able to pause the game anytime	[21]

Pedagogical Aspects

In pedagogical aspects, the game should contribute to the learning process (Table 6) on how player interact with the game as a pedagogical tool.

Table. 6 Pedagogical Aspect

H4. Pedagogy		
Guideline		Evidence
H4.1	Clear goal and learning objectives	[15]
H4.2	Learning tasks are interesting and engaging	[15], [20]
H4.3	The design and the contents are reliable and proven	[15]
H4.4	Can be used as self-directed learning tools	[15]
H4.5	Support for self-learning skills	[15]
H4.6	Medium for learning by doing	[15]
H4.7	Considers the individual differences	[15]
H4.8	Performance should be an outcome-based	[15]
H4.9	Offers the ability to select the level of difficulty in games	[15]
H4.10	Ability to work in their own pace	[15]
H4.11	Assessment tests that are aligned with the program objectives and content are provided, to check the player's progress at any time	[20]

Content

In content aspects (Table 7), it specifically concentrated on measuring the learning content. The learning content should provide informative, useful, and understandable content to users when playing the game.

Table. 7 Content Aspect

H5. Content		
Guideline		Evidence
H5.1	Reliable content with correct flow	[15]
H5.2	Clear and understandable structure of contents	[14], [15]
H5.3	The game provides learning content	[14]
H5.4	Navigation of content is easy and accurate	[15]
H5.5	Supporting materials are sufficient and relevant	[15]
H5.6	Materials are interesting and engaging	[15]
H5.7	Players able to understand the learning goal	[15]
H5.8	The learning objective from the game is achieved	[14]
H5.9	The content is chunk based on topic and subtopic	[15]
H5.10	Major and minor topic is differentiate clearly	[15]

IV. CONCLUSION

In this study, five studies on heuristics evaluations related to MGBL were reviewed and compared. Based upon the review of these five sets of heuristics, essential heuristics aspects for evaluating MGBL have been identified. Later, a new set of heuristics was proposed. There are five heuristics aspects for evaluating MGBL, such as Game Play, Game Usability, Mobility, Pedagogical, and Content. Each aspect consists of some guidelines that can be used as indicators to evaluate MGBL.

For the future work, a validation process is needed to obtain feedback and review from some experts. This study hopes to further implement the proposed heuristics aspects to investigate on the effectiveness of MGBL.

A future study will also be conducted to combine the proposed heuristics aspects with a current technology aspect. This new set of combined heuristics can help developer to evaluate the current technology related to MGBL.

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