A Review of Heuristics Component for Usability Evaluation of Mobile Educational Games

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Abstract

Digital games playing culture and widely-used of mobile devices among today's generations have prompted the practice of mobile games for learning purposes, known as mobile educational games. However, evaluating the usability (effectiveness, efficiency and satisfaction) of educational games for the mobile platform is challenging because of the features of educational game and mobile devices itself. Therefore, this study aims to review the evaluation components which are commonly evaluated to ensure the usability of mobile educational game. Literature review on previous studies that have proposed heuristics to evaluate the usability of two technologies context namely mobile games and mobile educational games was conducted. The findings of this study propose the evaluation components to evaluate the usability of mobile educational games.

Keywords: *Usability evaluation, mobile educational games, game evaluation, heuristics evaluation*

1. Introduction

Digital technologies like games have given us the opportunity to do so many things now. Games were typically played for fun and entertainment purpose. Nowadays it were used for more serious purposes such as health care, education and business (Aleem, Capretz, & Ahmed, 2016), which known as serious games, game-based learning (GBL) or educational games (EG). These terms are often used interchangeably in the literatures. By definition, serious games are game that is use for teaching and learning in various field (Paiva, Flores, Barbosa, & Ribeiro, 2016) but the one that is use specifically in education field is called EG (Hendrix & Backlund, 2013). EG is designed with the idea of using games to teach the player some subjects (Roungas & Dalpiaz, 2016) by integrates the educational content to achieve learning outcomes (Ibrahim, Khalil, & Jaafar, 2011), whereas GBL refer to the game that is use for learning purposes. This paper refers to these games henceforward as EG.

The prevalence of mobile technologies has increases the number of EG for mobile platform which called as mobile educational games (MEG) (Giannakas, Kambourakis, Papasalouros, & Gritzalis, 2018). This has positively increased the revenues of global game market. Newzoo, the global leader of games analytics, has reported that the revenues of global games market are expected to rise from $152.1

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billion in 2019 to $196 billion in the next three years with mobile games held more than half of the market share (59%) (Wijman, 2019).

EG was believed as effective learning tool as it can foster student's motivation to learn (Ibrahim et al., 2011; Papastergiou, 2009) and improves their educational performances (Huang, Chang, & Wu, 2017; Perry, Kulpa, Pinheiro, & Eichler, 2012). By using MEG, student can learn at their convenience because of its mobility feature. However, it was always a challenge for game practitioner to evaluate the effectiveness of MEG. Measuring the usability of any application for mobile platform are difficult since mobile devices of today are known with constraints that can hinder usability such as screen size, control or input interface and interruptions (Hussain, Saleh, Taher, Ahmed, & Lammasha, 2015). Moreover, ensuring the usability of EG was also challenging because it has to integrate both educational and gaming requirements (Omar & Jaafar, 2010).

Therefore, usability evaluation is recommended to ensure a greater level of usability. Fatta *et al.* (2018) have stated that the usability evaluation of EG was important in order to ensure its success. By definition, usability is the "*extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"* (ISO/IEC 9241-11). Usability can be evaluated by several evaluation methods, by the way user testing and inspection method are the most favoured (Dourado & Canedo, 2018).

Heuristics evaluation (henceforth refers as HE) is one of the most preferred usability inspection method (Mugisha, Nankabirwa, Tylleskär, & Babic, 2019) which sometime called as expert evaluation. This method can be conducted by three (3) to five (5) usability experts by checking the design of interface with usability principles to identify usability issues (Kumar & Goundar, 2019). The usability principles are called as "Heuristics". HE can be conducted from the early stage of game development without end user involvement, thus it was a cost-effective method (Tondello, Kappen, Mekler, Ganaba, & Nacke, 2016). Due to that, heuristics have been suggested in many studies for usability evaluation of various types of game. Hence, this paper aims to review the existing heuristics in relation to usability evaluation of MEG to identify the concerned evaluation components.

In games, HE and user testing method are frequently used to evaluate the usability (Fatta et al., 2018). HE is used by usability experts to inspect the game under construction during development process even when the game prototype is not yet exist. In contrast, user testing method (known as Play testing) can only be done with the existing of functional game prototype and end users. The end user is required to play the game prototype with aims to find usability issues. This method usually used to discover usability issues that might have missed by game practitioner during game development. Nonetheless, user testing is expansive, time consuming and require many resources to conduct. Korhonen *et al.* (2009) have reported that it was difficult yet costly to i) recruit enough end user for test session and ii) solve the issues when the game is almost done. Thus, game development team that cannot afford play testing opt for HE to evaluate their games' usability (Korhonen, 2016).

According to Aleem *et al.* (2016), HE is perform to identify usability issues in the software interface design but in games context it was insufficient to address only the issues concerning game interface. Since, games comprises of some other

components like mechanics, story and game play. Al-Azawi *et al.* (2013) stated that games should have their own heuristics. Due to that, researchers in the field have been proposed many heuristics for usability evaluation of various types of games. However, some of the heuristics are very generic and unable to address usability issues of some specific game types especially EG. Hence, several heuristics were proposed to support the weaknesses of the generic heuristics to discover more usability issues of the specific game types.

2. Related works

The existing studies that have proposed heuristics for usability evaluation in relation to MEG were reviewed in this section. This paper focused on studies that published in English only. The proposed heuristics were explained based on two sub context of technologies which are mobile games and MEG.

2.1 Heuristics for Usability Evaluation of Mobile Games

The first heuristics proposed for usability evaluation of mobile games was the one proposed by Nokia's researchers whos are Korhonen and Koivisto (2006). This heuristics concerned three (3) evaluation components including *Game usability*, *Mobility* and *Game play* as depicted in Figure 1.

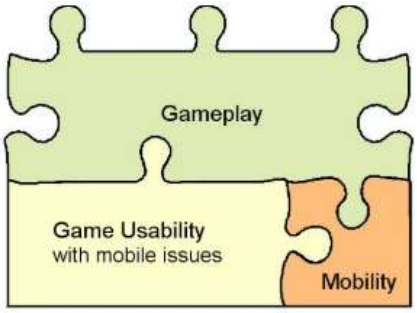

Figure 1. Heuristics Components for Mobile Games

The *Game usability* and *Game play* components were generic heuristics that can be used to evaluate the usability of any types of mobile games regardless of the platforms. *Game usability* component concerned on general usability of the games addressing the *interface* and *control* features where the player interact with the game. Game's interface is the first thing that the player will face, thus interface that have a good level of usability can ensure a pleasure playing session. There are twelve heuristics item that been proposed for this component as shown in Table 1.

Table 1. Heuristics for Game Usability component

Component	Heuristics
Game usability	Audio-visual representation supports the game.
	Screen layout is efficient and visually pleasing.
	Device UI and game UI are used for their own purposes.
	Indicators are visible.
	The player understands the terminology.

	Navigation is consistent, logical, and minimalist.
	Control keys are consistent and follow standard.
	Game controls are convenient and flexible.
	The game gives feedback on the player's actions.
	The player cannot make irreversible errors.
	The player does not have to memorize things.
	The game contains help.

For *Game play* component, it explains the play structure which player use to interact in the game. This component includes the aspect of *game mechanics* which was the basis for *game play* that determine the operation in the game world such as jumping, shooting, catching, punching and so on. This component includes also the aspect of *game story* that explains the sequences of event that happen in the game world. The proposed heuristics for this component are shown in Table 2.

Table 2. Heuristics for Game play component

Component	Heuristics
Game play	The game provides clear goals or supports player created goals.
	The player sees the progress in the game and can compare the results.
	The players are rewarded and rewards are meaningful.
	The player is in control.
	Challenge, strategy, and pace are in balance.
	The first-time experience is encouraging.
	The game story supports the gameplay and is meaningful.
	There are no repetitive or boring tasks.
	The players can express themselves.
	The game supports different playing styles.
	The game does not stagnate.
	The game is consistent.
	The game uses orthogonal unit differentiation.
	The player does not lose any hard-won possessions.

This heuristics focused also on *Mobility* component that deal with issues in relation to mobile. The heuristics was proposed based on the analysis of mobile phones's features and its context of use. The issues that often encountered when using mobile phones are ligthing and noise during outdoor usage, immediate operation mode without delay, inevitable interruptions like incoming call or receiving text and delayed options for external events. Sometime the limitation of mobile features such as screen size, batery life, processing speed and audio capacity should also be taken into account when designing mobile games. Table 3 listed the proposed heuristics for evaluating mobility of games. This heuristics has been validated and the results shown that it was useful in discovering usability issues of mobile games.

Table 3. Heuristics for Mobility component

Component	Heuristics
Mobility	The game and play sessions can be started quickly.
	Interruptions are handled reasonably.

	The game accommodates with the surroundings.

In 2007, these researchers has extended their heuristics for mobile games by proposed specific *Game play* heuristics for mobile games with multi-player feature (Korhonen & Koivisto, 2007). The existing *Game play* heuristics fails to uncover the usability issues in concern to *multi-player* feature. Multi-player is a mode of game playing where two or more player plays the game in one session at the same time. This mode is more challenging and exciting compared to single player because player can interact with other player which is not the artificial intelligent system. The proposed heuristics are shown in Table 4. This heuristics has been validated and the result has shown that it has completed the existing heuristics for mobile games. This *multi-player* heuristics can be used to evaluate usability of various types of mobile games and other application.

Table 4. Heuristics for Mobile Multiplayer component

Component	Heuristics
Multiplayer	The game supports communication.
	There are reasons to communicate.
	The game supports groups and communities.
	The game helps the player to find other players and game instances.
	The game provides information about other players.
	The design overcomes lack of players and enables soloing.
	The design minimizes deviant behavior.
	The design hides the effects of the network.

Due to advancement of mobile technology, Soomro, Ahmad and Sulaiman (2012) has expanded the Nokia's heuristics for mobile games. They proposed new heuristics item for the existing component by focused on the one that has not been proposed by previous researchers. By conducted evaluation of more advanced mobile games, they found new usability issues that are fails to be uncovered by the existing heuristics. Therefore, they proposed new heuristics to cater the encountered usability issues. Table 5 shows the additional items for mobile game's heuristics.

Table 5. Heuristic for Mobile Games

Component	Heuristics
Game usability	Player able to skip movies & images (non-playable).
	Game allows customization.
Mobility	Game can handle interruptions (internal).
	Player able to pause the game anytime.
Game play	The player able to save the game anytime.
	Game objectives are moderate (not too easy, nor too difficult).
Multiplayer	Multi-player sessions can be easily created.
	Game sessions can be saved & restored in loss of connectivity.
	Game supports multiple connectivity medium.
	Game supports multiple ways of communications (voice & text).

Moreover, evolvement of touchscreen mobile devices has made the usability evaluation of mobile games more challenging due to limitation of use especially in the control aspect. Mohd, Daud and Mokhtar (2016) have proposed specific heuristics for evaluating the *control* feature of mobile games. They extracted the

existing guideline in relation to design and evaluation of *control* feature from previous studies including user interface heuristics by Nielsen (1995), iPhone and Android Design by Mark Overmar, Eight Golden Rules by Shneiderman, video games heuristics by Federoff (2002) and Desurvire and Wiberg (2009), and heuristics for touchscreen mobile devices by Inostroza *et al.* (2012). However, the proposed heuristics is not validated yet. The proposed heuristics for mobile game's control feature and its sub-components are shown in Figure 2.

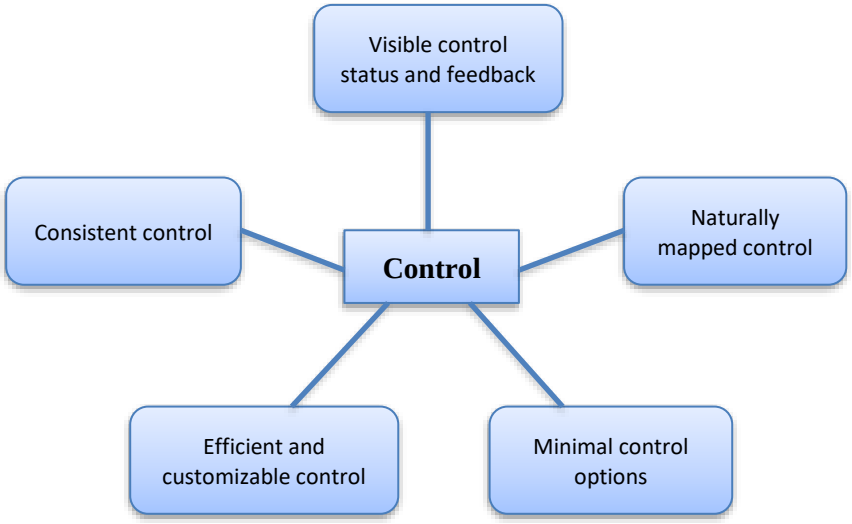

Figure 2. Heuristic for Control component

2.2 Heuristic for Usability Evaluation of Mobile Educational Games

In this section, the heuristics proposed particularly for usability evaluation of MEG were studied. This aims to identify the suggested evaluation components to address the educational aspects of game. Zaibon and Shiratuddin (2010) has proposed heuristics for usability evaluation of MEG. This heuristics was adapted from Nokia's heuristics for mobile games and proposed one new evaluation component. This heuristics comprises of four (4) components including *Game usability*, *Mobility*, *Playability* (called as *Game play* in previous heuristics) and *Learning content* as depicted Figure 3.

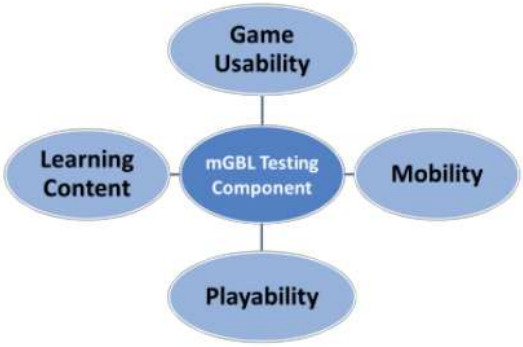

Figure 3. Heuristics Components for MEG

The first three (3) components were adapted from the existing heuristics. The changes have been made to the description of heuristics item and irrelevant heuristics items were removed. For *Game usability* component, two heuristics items were removed, whereas in *Game play* component four (4) heuristics items were removed. However, there is no improvement made on the *Mobility* component. For *Learning content*, this is the additional evaluation component proposed to evaluate usability issues in MEG's content so that it can provide useful information and understand by player during game session (Zaibon, 2015). The proposed heuristics are shown in Table 7.

Table 7. Heuristics for Learning Content component

Component	Heuristics
Learning content	The content can be learned easily.
	The game provides learning content.
	The learning objective from the game is achieved.
	The content is understandable.

This heuristics was validated as useful to evaluate MEG. According to Fatta *et al.* (2018) in their study on usability evaluation of MEG, Zaibon's heuristics consist of comprehensive heuristics component for usability evaluation of MEG. However, for specific context, this heuristics did not address the issues of *Pedagogy*. Therefore, they pointed out that context-specific heuristics should be added for the existing heuristics. For example, they proposed evaluation component that reflects children learning and children behaviour to address more usability issues.

A study by Machado *et al*. (2018) is another example of study that proposed context-specific heuristics. They proposed heuristics for design and evaluation of MEG for older adult user. The heuristics focused only on the *Game play* component. These authors have conducted a research on the usage of mobile devices by older adult. Then, the existing *Game play* heuristics was adapted to match the context of use of older adult. The proposed heuristics was used to develop MEG that aims to teach older adults on how to use smartphone's features.

3. Discussions

The review of heuristics for usability evaluation of mobile games has shown that *Usability (interface)*, *Game play*, *Mobility* and *Control* are the concerned evaluation components, whereas in MEG context, the studies focused on *Usability (interface)*, *Game play*, *Mobility*, *Learning content* and *Pedagogy* components. *Usability* component is the basic component for usability evaluation of any kind of games. This component usually addresses the *interface* and *control* aspects of game because the game with good interface and control can ensure good usability. *Game play* component is evaluated because it is the basic game design aspect which includes the *mechanics* and *story* of game. Besides, the *Mobility* component should be evaluated when designing game for any mobile platform to address the domain-related usability issues. Furthermore, when it comes to EG, *Learning content* and *Pedagogy* components were evaluated. Importantly, in order to ensure the effectiveness of EG regardless of platforms, we must evaluate the usability issues from both gaming and educational aspects. Therefore, the finding of this paper can

help game practitioner to evaluate MEG or future research to choose relevant evaluation component to develop the heuristics for MEG. Figure 4 illustrated the proposed heuristics components for usability evaluation of MEG.

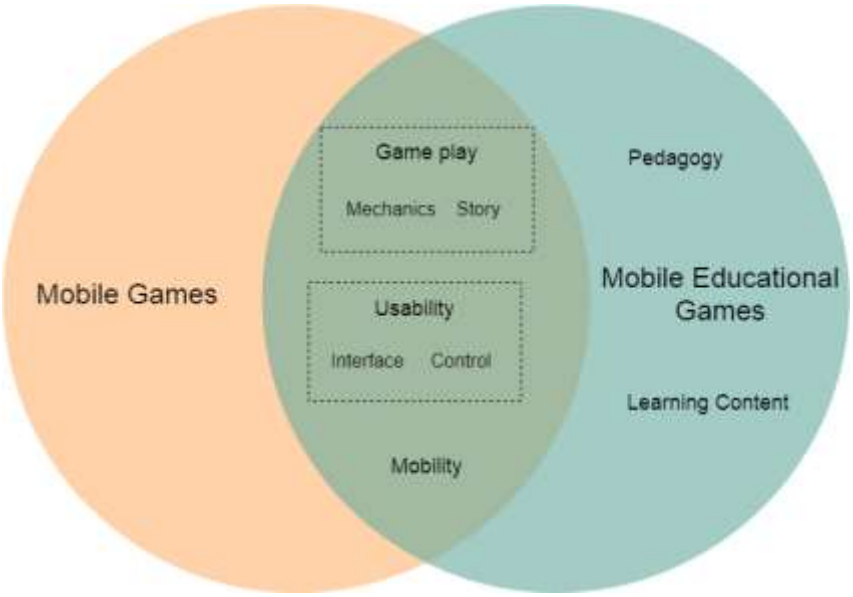

Figure 4. Heuristic Components for Mobile Educational Games

4. Conclusion

The advancement of mobile devices has introduced EG for mobile environment. Ensuring the usability of MEG was challenging because of the EG characteristics and platform limitations. Many heuristics has been suggested in the past studies for evaluating usability of different games types. However, within the MEG context, those heuristics cannot be exploited directly. Thus, the evaluation components of existing heuristics for usability evaluation of mobile games and MEG were identified. Finally, the proposed evaluation components for usability evaluation of MEG were presented. For future research, the suggested components will be used to develop a comprehensive heuristics for usability evaluation of MEG. Further validation is highly recommended to identify other evaluation component to support the findings of this paper.

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