

Heuristics Evaluation Strategy for Mobile Game-Based Learning (mGBL)

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Abstract

Evaluation of learning media is necessary for determining the effectiveness of the produced media. When evaluating mobile game based learning (mGBL), conventional usability heuristics evaluations lack comprehension and difficult to be directly implemented. Therefore, heuristics evaluation strategy is proposed to evaluate specifically mGBL. The strategy consists of four components: Game Usability, Mobility, Gameplay, and Learning Content. Each of the components represents the issues to be considered and evaluated for mGBL. In addition, a prototype of mGBL is developed and evaluated by utilizing the proposed strategy. The results indicate that the strategy is useful and potential to be implemented for other mGBL applications.

1. Introduction

mGBL is a game-based learning that utilizes mobile technologies such as mobile phone, PDA and handheld devices for playing platform. Mohamudally [1] describes that the concerning issues of mGBL are mobility and restrictions on mobile technologies. He further states the mGBL concepts are grounded in pedagogical theory and adjusted to the technical capabilities of current standard mobile phones.

mGBL applications are developed for a broad variety of learning contexts such as role play and multiplayer games [1], [2], [3], [4]; or GBL of C++ [5]. Some mGBL applications focus on collaboration [2], [6]; and on the contrary others are mainly played individually [7].

Mitchel et al. [8] have proposed the three year pan-European funded project, which prototyped mGBL in three sectors: i) e-health, ii) e-commerce, and iii) career guidance. The project was based on research findings that have been conducted by Mitchell [8]; Mitchell and Savill-Smith [9]. The findings show that

mGBL is considerable potential for promoting and encouraging learning.

2. Study on mobile learning preference

The main objectives of this study are to find out the specific target audiences for mGBL and their preferences in learning. Basic statistical method was used to assess the student responses which were based on descriptive technique. Two months (between August to September 2008) were allocated for the data collection period. The targeted samples were among students at Malaysian secondary schools. They were randomly selected in different background of school types which range from urban to rural areas and public to boarding schools.

As illustrated in Table 1, about 61.9% of the respondents are female and the remainder male. As for race composition, the majority of the respondents were Malay (81.4%), while the rest were Chinese (9.1%), Indian (8.1%) and other races (1.3%). Other races include Aborigines and Siamese. From the result, we found that majority of the respondents with 73.9% have access to mobile phone. However, it was noted that fewer respondents (aged 13) did not have access to mobile phone as compared to other group of ages.

Table 1. Demographics profiles

	Gender		Total
	Male	Female	
Ages			
- 13 (Form 1)	71	95	166
- 14 (Form 2)	12	94	106
- 15 (Form 3)	30	62	92
- 16 (Form 4)	65	65	130
- 17 (Form 5)	47	50	97
Total	225	366	591

First question in the instrument, regarding whether they play mobile games, 437 students answered (see Figure 1). Most of them (69.8%) reported that they play mobile games (n = 305); of these, 40% players

were males, and 60% were females. Here, it can be concluded that female students like playing mobile games. In addition, it can be seen that girls (68%) like to play mobile games as much as boys (72%).

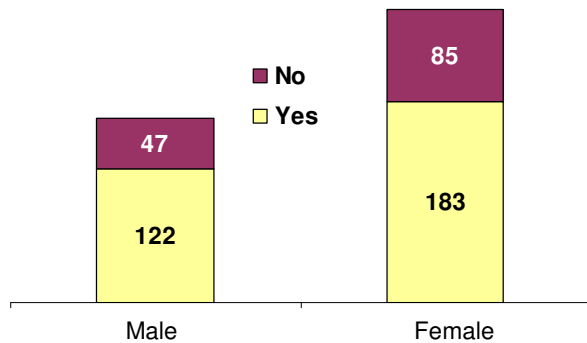


Figure 1. Play mobile games

Next, when the students were asked about the purpose why they play games (in general), they were given three items from which to select: entertainment, education, and both. 577 students responded to this question. As seen in Table 2, most of the students stated that they play games for entertainment (50.4%); the next highest category is both (45.8%). Very few students reported playing games for education only.

A comparison of males' and females' aims in game playing reveals some differences. For example, males play games more than females for entertainment: 52.0% of the males played games for entertainment, while only 49.4% of females did so. On the other hand, the females scores higher (46.3%) reported that they play games for both reasons; while 44.8% of the males cited this reason. This suggests that, in order to make the mGBL successful in learning environment, it should embrace both entertainment and education purposes.

Table 2. Purpose for playing Games

	Gender		Total
	Male	Female	
Entertainment	52.0%	49.4%	50.4%
Education	3.2%	4.3%	3.8%
Both	44.8%	46.3%	45.8%

In Table 3, when they were asks what they want to learn from a game, 79.1% prefer learning the general knowledge compared to other subject areas.

Generally, the results in the study are consistent with previous studies (for example Lee [10]; Norbayah & Norazah [11]; Business Wire [12]; and Hafizullah [13]). The results reveal that a majority of the surveyed

students have access to mobile phone. Most of them played mobile games, and female students played more than males. The finding also disclosed that, in order to make the mGBL successful in learning environment, it should embrace both entertainment and education purposes. In addition, students preferred learning general knowledge rather than school's subject using mGBL.

Table 3. What do you want to learn from game?

Knowledge	Frequency (n=565)	%
Cultural & Heritage Values	155	27.4
General Knowledge	447	79.1
Tourism	255	45.1
Economic & Business	160	28.3
Medical & Health	136	24.1
School's Subject	223	39.5
Others**	65	11.5

Consequently, this study provides (i) evidence that there is a huge potential in implementing mobile game for educational purpose, and (ii) indication that mGBL is preferred to be useful in learning general knowledge. Therefore, a mGBL is developed based on the findings of the study which described in the next section.

3. mGBL of 1M'sia game development

A mobile game based learning (mGBL) about local content that could foster the concept of 1Malaysia (<http://www.1malaysia.com.my>) is produced. The game is named 1M'sia which is abbreviated from one Malaysia.

The mGBL development is primarily based on the concept of "edugaming" by [15] and "game-based learning" by [16] which focuses on intertwining learning and gaming. The characteristics of 1M'sia mGBL are adapted from the learning theories and approaches discussed in previous sections. Although not all characteristics are adapted, a few are obvious to be implemented in 1M'sia mGBL characteristics.

The mGBL developed for this study is opted for the Flash platform. Four design and development phases are involved (as illustrated in Figure 2): (i) Analysis (ii) Game Design (iii) Development, production and integration; and (iv) Evaluation.

In the analysis phase, the target user is defined which range from 9 years old children to adult. Besides, the mobile technology and restrictions are analyzed for the targeted platform. The most important aspect is the learning content analysis. The values of

1Malaysia concept are chosen for the learning content of the mGBL. In the game design phase, a group of activities are conducted such as storyboarding, game flow design, interface design, and navigation structure design. From here, the real development phase will then take place. In the development phase, all game sources are integrated through authoring and programming steps using Flash tool. The game sources include vector images and graphics, text, sound, and music which provide the learning content. At the final phase, the game is tested for verification to ensure that the game is playable at mobile phone without errors and bugs. Amendments are made for any errors occurred during testing. Lastly, the game is deployed to mobile phone and available for playing.

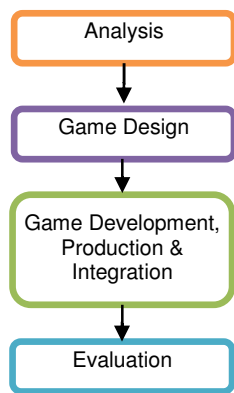


Figure 2. mGBL development stages

3.1. Learning content of 1M'sia mGBL

In tapping the thriving mobile business, a study on mobile content development, specifically local ones is urgently required. Highly wanted local contents development is indeed for education, entertainment, and games. Thus, a mobile game based learning (mGBL) about local content that could foster the concept of 1Malaysia (<http://www.1malaysia.com.my>) is produced. The mGBL can subtly assist users in learning the useful information that the values of 1Malaysia are conveying. This is necessary for the successful of promoting harmonious and unity amongst the multi-ethnic citizen of Malaysia. The values of 1Malaysia that are incorporated in the mGBL contents provide the basis of the mGBL play rules and actions.

The 1Malaysia formula is conceptualized for implementation in two main aspects. The first is through the assimilation of the (i) Principles of Unity, while the second aspect is the assimilation of (ii) Aspirational Values. Such values that are incorporated in the mGBL:

- Principles of Unity

- Acceptance amongst all races and peoples of Malaysia. The game shows how to shake hands with others.
- Humility in forming decisions and actions. The game shows the important of queuing.
- Mutual respect to others. The game guides to know and respect other races cultures as well as to elderly people.
- Aspirational Values
 - Integrity in all matters and transactions. The game portrays the responsibility on tasks/ jobs.
 - Culture of education. The game shows the situation in school.
 - Culture of precision in terms of time management and improving efficiency. The game demonstrates the time management policy.

3.2. Gameplay and flow of 1M'sia mGBL

The 1M'sia mGBL is aimed at demonstrating the values and challenging knowledge capabilities of the players of 1Malaysia values. In general, the game is generated into two game plays which are simple quiz and mix-and-match. Players act as a Malay character and then are triggered with several situations which provide the 1Malaysia values. Such situations are an ATM machine, a traditional costume shop, a house, a group of people, a school, and religious places. The players then have to enter the situation for the game environment. The players' skills and knowledge will determine how well they are able to do the right things, and the values will either be mastered or not. Figure 3 shows the 1M'sia game flow.

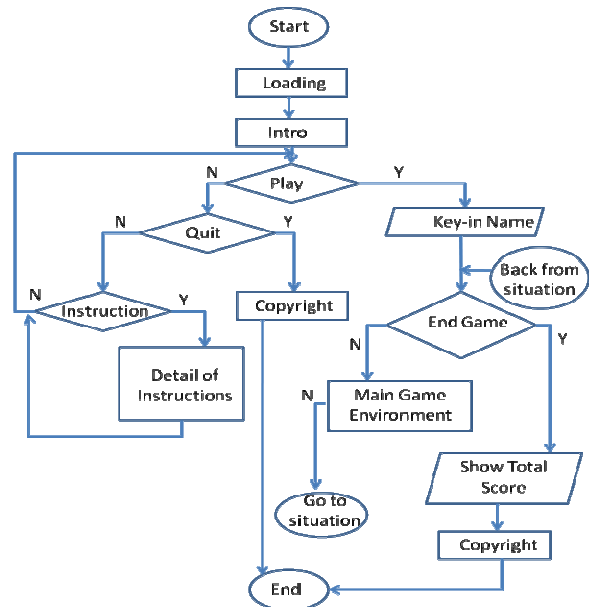


Figure 3. 1M'sia game flow

At the end of the game main environment, the player is shown to their own score of the level of their 1Malaysia concept comprehension. If the score is more than 70%, player's comprehension is acceptable for the knowledge level.

3. 3. Screen shots

The following screen shots (Figures 4 to 10) illustrate the user interface and screens of the 1M'sia mGBL. At first when the game is loaded, the main page is displayed. Players can continue to start playing the game by pressing start button or selecting other buttons for instructions. The game will start at main game environment, and players can control the game by pressing the arrow and selection keys.

Figure 4 shows the main environment of the 1M'sia mGBL. Figure 5 and 7 are examples of situations that player will be triggered. For example in Figure 5, when player enters the situation, a short animation will be displayed that shows the 1M'sia value and then give a simple quiz. The example shown in Figure 6 is a quiz of Humility value. Once the answer is selected, score will be shown. After that the player will get back to the main environment to proceed for the next situations provided in the main game environment.

Figure 8 and 9 show an example of a mix-and-match game where the player needs to match the correct traditional costumes for the specific ethnic group in Malaysia. The game immediately informs the player whether the answer is right or wrong. On Figure 10 shows a simple summary given at the end of the game, where the player is informed of their total percentage that player has been achieved. The percentage indicates the level of player comprehension of 1Malaysia values.



Figure 4. Main environment of 1M'sia mGBL



Figure 5. Situation and value of 1M'sia mGBL



Figure 6. Simple quiz

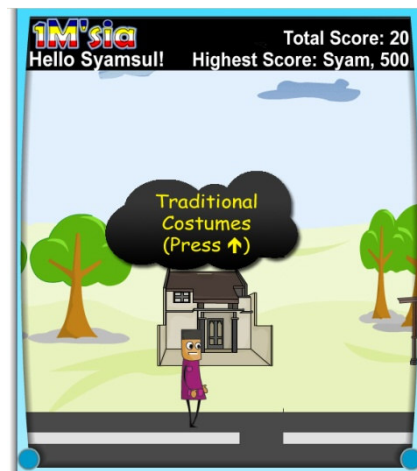


Figure 7. Traditional costume store



Figure 8. Mix-and-match game



Figure 9. Correct answer of Mix-and-match game



Figure 10. Final score

4. Porting and Testing of mGBL

Among the final mGame development stages usually involve porting and testing. Porting is making changes to the game in order to make it run on different environment. In mGame development, porting is the most challenging phase where the game has to run on a large number of models and also has to cover most new models for it to be put on market. Unlike the other gaming devices, in mobile gaming there are hundreds of devices. Normally, porting can be cross platform porting (J2ME to Brew and Brew to J2ME), operator specific porting (Cingular, Vodafone, T-Mobile, Orange, Maxis, Digi, etc), and Flash Lite and Symbian porting.

Testing a game is mandatory in ensuring there is no crash or inconvenience for players. To test a game, it is not enough to do it on emulators. Emulators cannot replace the real phones since they can only be trusted for 10% of assurance [17]. Moreover, not all devices have emulators. Testing a game on real devices is a must for all developers to experience the screen and memory issues. It is suggested that developers test and re-test the final product on real phones. Due to the nature of this fragmented medium, developers will need access to at least 10 to 20 mobile phones [17].

The game testing was conducted by following the suggestions [18] and [19]. They categorize the testing into these dimensions:

- i. Functionality - stability (does the game crash?), correctness of game mechanics (do the control keys function correctly?), integrity of game assets (do multimedia elements in good quality)
- ii. Compliance - formatting of standard error message, handling of memory card data, handling of legally trademarked/ copyrighted materials, fulfilling particular content rating
- iii. Compatibility - the game can be played on different devices? the game can be played on different platforms? the game can be played on different device specifications?
- iv. Localization – suitability for different countries and languages
- v. Soaking - soaking testing was conducted by leaving the mGBL running for a period of hours in various modes of operation, such as idling or paused without any user interaction. The purpose of soaking is to know the stability of the game.

Overall, the game technical testing was successfully conducted. As a result, the game is running properly and contains no major errors; nevertheless the mGame is only compatible with PDA and smart phone. The main objective of conducting the testing is achievable

by knowing that the game is playable although on certain mobile devices.

5. Heuristics Evaluation Strategy for mGBL

Heuristics evaluations are developed for evaluating the effectiveness the application commonly in usability aspect. The usability evaluation is conducted to users in order to find out how easily and efficiently the users can achieve the application goals. There are a lot of usability evaluations which are those originally developed by Nielsen and Molich [20], Nielsen [21], and now the current list of usability heuristics in [22]. Additions have also been made to the evaluation such as by Muller et al. have added three new heuristics that they have considered to be useful [23]. In specific to educational games, Malone has created the first heuristics for evaluating educational games [24].

In this study, it is considered to use these heuristics or tools in the evaluations, but they were not feasible because of three reasons. First, the existing heuristics did not deal with mobility issues, which is one of the main target platforms. Second, the heuristics were not described the learning content. Third, some of the heuristics were overlapping, which made them ambiguous. Therefore, a set of heuristics are adapted from Korhonen and Koivisto [25] by adding a new component which is a learning content that would overcome the learning context in mGBL.

The game usability components (Table 4) depict the interface and game controls which the player interacts with the game. In general, good game usability ensures that the player have interest to play the game until the end.

Table 4. Game usability components

No.	Game Usability Components
GU1	Audio-visual representation supports the game
GU2	Screen layout is efficient and visually pleasing
GU3	Device UI and game UI are used for their own purposes
GU4	Navigation is consistent, logical, and minimalist
GU5	Control keys are consistent and follow standard conventions
GU6	Game controls are convenient and flexible
GU7	The game gives feedback on the player's actions
GU8	The player cannot make irreversible errors
GU9	The player does not have to memorize things unnecessarily
GU10	The game contains help

In Table 5, the mobility components concern about the issues that affect mobility of the game. Mobility can be defined as the easiness of a player to enter to the

game world and the accessibility of the game at anywhere and anytime.

Table 5. Mobility components

No.	Mobility Components
MO1	The game and play sessions can be started quickly
MO2	The game accommodates with the surroundings
MO3	Interruptions are handled reasonably

Gameplay components (Table 6) describe how the game is playable, run smoothly, meaningful, and not bored to player.

Table 6. Gameplay components

No.	Gameplay Components
GP1	The game provides clear goals or supports player created goals
GP2	The player sees the progress in the game and can compare the results
GP3	The players are rewarded and rewards are meaningful
GP4	The player is in control
GP5	Challenge, strategy, and pace are in balance
GP6	The first-time experience is encouraging
GP7	The game story supports the gameplay and is meaningful
GP8	There are no repetitive or boring tasks
GP9	The game does not stagnate
GP10	The game is consistent

Whereas in learning content component (Table 7) are specifically concentrated on the learning content whether it is informative, useful, and understandable.

Table 7. Learning content components

No.	Learning Content Components
LC1	The content can be learned easily
LC2	The game provides learning content
LC3	The learning objective from the game is achieved
LC4	The content is understandable

5.1. Evaluation sessions and methods

In addition to the porting and testing stage, we also conducted a heuristics evaluation study of the mGBL. Therefore, in order to evaluate the perception of users about 1M'sia mGBL, the proposed heuristics evaluation strategy was used. The evaluation sessions have been conducted in October 2009 during the International Exposition of Research and Inventions of Institutions of Higher Learning 2009 (PECIPTA 2009) at Kuala Lumpur. Visitors who came to our booth were randomly asked to play the 1M'sia mGBL and at the end of the three-day expo, 85 visitors tried the mGBL. All visitors played the mGBL using the devices that were provided to them.

The evaluation sessions were conducted during this exposition because researchers were interested in seeing the participants in a natural setting while playing the mGBL and to get a better sense of them without having any formal circumstances. The questions (5 Likert scale) were asked spontaneously which were basically aimed at game usability, game mobility, gameplay, and learning content (Table 4 to 7).

6. Findings and discussion

This section presents the findings of the evaluation strategy and analysis of the main results. The discussion is intended to highlight the key issues that arise from the responses obtained. First, the demographic profile of the users is illustrated in Table 8.

Table 8. Demographics profiles

		Gender		Total
		Male	Female	
Ages	9	3	2	5
	10	4	2	6
	11	2	3	5
	12	2	5	7
	13	4	8	12
	14	6	4	10
	15	2	3	5
	16	7	13	20
	17	6	4	10
	Total		36	44

Figure 11 and 12 show the user evaluation study taking place at the expo. Table 4 shows the demographics of the children who participated in the study.



Figure 11. Users playing 1'Msia mGBL



Figure 12. Conducting the evaluation

The first component of the evaluation is game usability. As seen in Figure 4, overall min = 3.7 and the highest score is GU6. It can be concluded that the mGBL is average in term of its usability aspect.

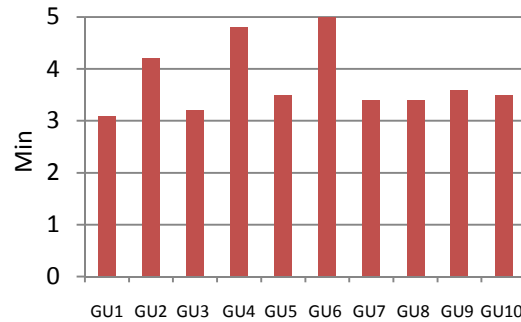


Figure 13. Game usability components

Second component is the mobility issue. Figure 5 shows that overall min = 3.3 and this can be expected that the mGBL suits the mobility component.

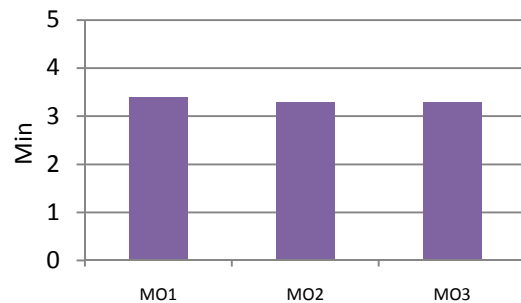


Figure 14. Mobility components

Next component is the gameplay component. Figure 6 depicts that the overall min = 3.6. The highest score is GP4 and the lowest is GP6. Although the scores are

not consistent, the game is expected by users to be more adventurous rather than simpler version of the mGBL.

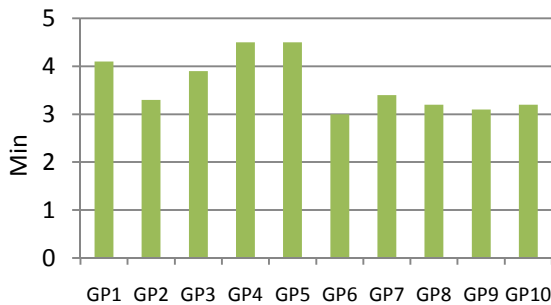


Figure 15. Gameplay components

Lastly, the component that is important for learning objective is the learning content. It is obvious that the overall min= 4.0 which indicates that the learning content is really informative, understandable and easy to learn.

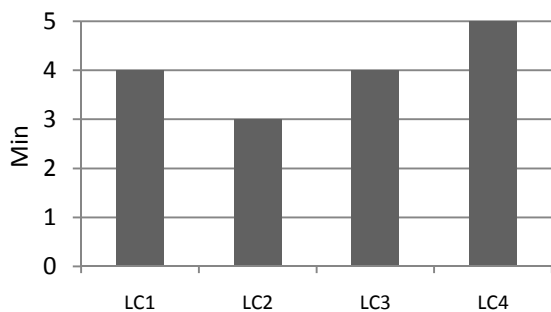


Figure 16. Learning content components

7. Conclusion and future study

The main deliverables of this study are the mGBL itself and the heuristics evaluation strategy. Although the mGBL is a at beta version, the research has shown that the mGBL has potential to be a learning tool and marketed since it is seen as unique to Malaysia.

The heuristics evaluation strategy concerns with these components: game usability, mobility, gameplay, and learning content. Overall, the evaluation sessions were successfully conducted and employed to the 1M'sia mGBL. It was simple to conduct, and provided an easy heuristics evaluation of similar concept of mGBL applications.

A number of future considerations can be suggested for this project, for example the heuristics evaluation

strategy should be extended to include further data analysis such as hypothesis testing and correlation analysis. Such findings can perhaps provide richer information and more discussions. In addition, the evaluation session can be conducted to other mGBL applications.

8. Acknowledgement

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