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USER TESTING ON GAME USABILITY, MOBILITY, PLAYABILITY, AND LEARNING CONTENT OF MOBILE GAME-BASED LEARNING

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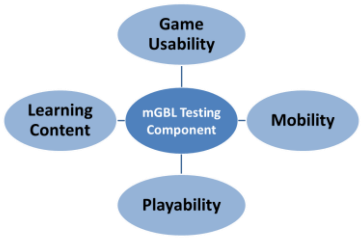

Abstract

This article presents an approach to user testing of mobile game-based learning (mGBL) applications by adapting four testing components: Game Usability, Mobility, Playability, and Learning Content. Each of the components represents the issues to be considered and evaluated for a mGBL. Therefore, the testing will know whether mGBL applications are well met each those needs of the components. 20 users were selected to play three different mGBL applications, and then they tested the game by completing testing forms. Users need to indicate whether each mGBL application met the need for each testing components. The findings show that users successfully played and completed all testing forms. The study provides intensive review of mGBL characteristics that can be useful and may be of interest to game developers.

Keywords: mGBL, mobile game-based learning, user testing

Abstrak

Artikel ini membentangkan satu pendekatan ujian pengguna terhadap aplikasi pembelajaran berasaskan permainan mudah alih (mGBL) dengan menggunakan empat komponen ujian: Kebolehgunaan Permainan, Mobiliti, Kebolehmainan, dan Kandungan Pembelajaran. Setiap komponen mewakili isu-isu yang perlu dipertimbangkan dan dinilai untuk mGBL. Oleh itu, pengujian ini akan mengetahui sama ada aplikasi mGBL memenuhi keperluan komponen-komponen tersebut. Seramai 20 pengguna telah dipilih untuk bermain tiga aplikasi mGBL yang berbeza, dan kemudian mereka menguji setiap aplikasi mGBL tersebut dengan melengkapkan borang pengujian. Pengguna perlu menentukan sama ada setiap aplikasi mGBL memenuhi keperluan bagi setiap komponen pengujian. Hasil penemuan menunjukkan bahawa pengguna berjaya bermain dan melengkapkan semua borang pengujian. Kajian ini memberikan ulasan yang intensif tentang ciri-ciri mGBL yang berguna dan mungkin menarik minat pembangun permainan.

Kata kunci: mGBL, pembelajaran berasaskan permainan mudah-alih, pengujian pengguna

1.0 INTRODUCTION

Mobile games used in m-learning environment offer rich and interactive learning experience, in which game play strategies are used to enhance learning by promoting learning through motivation aspect. Through mobile games, the playing activities will engage and stimulate cognitive, as well as promote teamwork among students, build skills, and interact with problems in mobile platforms [1]. As a matter of fact, Rieber [2] argues that as human beings by nature, one begins to learn through games and

playing from early childhood. Anyone at all ages would love to play games either in traditional of digital games.

Consequently, up until now games are replaced by formal learning at kindergarten. In our modern day, with the new technological advancements in learning, traditional games have been replaced by digital games (computer, console, and mobile games). Hence, digital games have been parts of contemporary learning nowadays [3]. Furthermore, the method of learning through mobile devices is becoming popular and this is shown by the growing numbers of available m-learning applications [4], [5].

Although there are many types of m-learning applications, this study focuses on the mobile game. Mobile game for learning or mGBL is a type of game specifically utilized for learning which is able to run on a mobile phone, smart phone, PDA or handheld devices [6]. Similar to game-based learning (GBL), the main aim of mGBL is to use game play to enhance motivation in order to learn, engage in knowledge acquisition, enhance effectiveness of learning content transfer and get benefit from other specific learning outcomes [7], [8]. Research on GBL and mGBL increases dramatically worldwide [9] due to the fact that the growing usage and popularity of exploiting game to support learning [10] and the advancement of mobile technology.

In the next section, variety of learning impact evaluation methods will be further described.

2.0 LEARNING IMPACT

There exists a large variety of methodologies to evaluate the educational impact of mobile learning tools [11]. Price and Oliver [11] proposed a research framework to evaluate educational impact that grouped all methodologies into three groups: anticipated, ongoing, and achieved impact. Anticipated impact refers to the description of the intentions that a specific educational tool has, and its results are relevance for policy makers. The results would produce some recommendations for further decision making process by the organization. On the other hand, ongoing impact refers to the evaluation of practices and is typically shared with others. This type of evaluation can be also referred to scholarship of teaching and learning (SoTL). Lastly, achieved impact promotes particular kinds of learning outcomes. Learning outcome for subjects or modules will be focused on for student's achievements.

However, this study focuses on anticipated impact as the testing method where the testing procedure is conducted to different users who do not intended to learn the content. The users test the mGBL based on their playing experience. In terms of impact measurement, Sharples [12] distinguished between impact measured as learning gains of the student (effectiveness); impact measured as motivational changes (satisfaction, and impact measured as usability of the tool) [12], [13]. For example, Vavoula *et al*. [14] analyzed the educational impact of Myartspace through qualitative analyses based on structured diaries and interviews to measure both effectiveness and satisfaction in informal learning environments. On the other hand, Ramos used a mixed-method approach with interviews and logs to evaluate the effectiveness of a mobile learning tool for non-formal, distance education [15].

Based on study conducted by Zaibon and Shiratuddin [16], this study focuses on the use of four testing components (Game Usability, Playability, Mobility, and Learning Content) to evaluate three mGBL applications in informal environment. However, this study will not analyze the specific learning impact as suggested by [12]. The chosen mGBL applications are described in the next section.

3.0 MGBL APPLICATIONS FOR TESTING

This study has chosen three mGBL applications for the testing as described in this section: Oh My English! Words, Educational Game Words, and Ninja Math. These mGBL are chosen randomly and its popularity from Google Play and App Store.

3.1 Oh My English! Words

"Oh My English! Words" is an educational game that is designed to improve children English vocabulary. The game is powered by FleaTech and developed by FencingFleas and it hits the top of Malaysian iOS and Android app stores. The game was developed in collaboration with Astro Malaysia (MEASAT Broadcast Network Systems Sdn Bhd) and is based on the popular Malaysian TV show, named "Oh My English!". The instructions of the game are very easy and simple to understand. Player just need to act as the main game character named as Mr. Middleton and as students of SMK Ayer Dalam to form words using the letters provided and score points (Figure 1).

There are ten places which selected as the environments used in this game that act as game levels. These levels are SMK Ayer Dalam, Classroom, Corridor, Canteen, Computer Room, Library, Football Field, Staff Room, Puan Hajar's Office, and School Hall. Each level contains ten sections and has different difficulties. Each level also includes two sections for Quiz Time. Each quiz section has five simple questions that need to be answered by the player.

In gameplay, players need to form words in limited moves and will be given points (Figure 2). They need to form as many words as they can in order to get higher points. Rewards are given in the form of gold coins which then will be used to buy boosters to complete all the designated levels. Players are able to check the meaning of certain words if they do not know the meaning. This game will automatically connect to a dictionary in a website and the player could find the word meaning easily. The main advantage of the game is its benefits for English Education because it

helps players to form variety of words that might be never know before.

Figure 1 Oh My English! Word Game

Figure 2 Oh My English! Word Game

3.2 Educational Game- Words

"Educational Games – Words" game is the latest educational game in the line of free educational mobile applications from the SCIENCE4YOU applications (www.science4youtoys.co.uk). This mobile game was designed for children to learn from the beginning of knowing ABC until writing words. The game provides four fun educational games, which will help them to learn all the letters from A to Z, and writing words from Ant to Zebra. "Educational Games – Words" game is developed by teachers, specialists, and parents, aiming to encourage the learning capabilities of children, regarding letters and words (Figure 3). With the free version, kids will spend endless hours playing the game that teaches them the ABC letters and at the same time helps them to develop their cognitive and manual skills, cognitive memory, concentration, reading, writing, and verbal capabilities.

In term of gameplay, the game gives the kids chances to learn all the letters in the alphabet in an easy and fun way (Figure 4). With four different games types which each of that includes four levels of difficulties:

(i) drawing letter: teaches the kids how to draw all the letters in alphabet correctly, from vowels to consonants, according to the selected difficulty level;
(ii) missing letters: the kids will be challenged to discover the missing letter. As the game level increases, so do the difficulty and the number of letters to identify;
(iii) finding letter: the kids need to identify which is the missing letter, with the help of a fun illustrative image. With a ranking system for each level so parent can track the kid's progress. This can helps to reinforce the kid's ability to correctly identify the letters of the alphabet and correctly complete all words;
(iv) matching pairs: it challenges the kids to discover the matching pair of each image within the time provided. It is an image matching game for kids, designed to provide hours of entertainment and fun.

Figure 3 Educational Game- Words

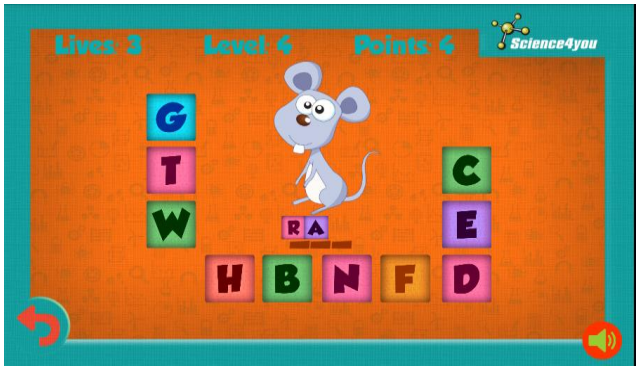

Figure 4 Educational Game- Words

3.3 Ninja Math

Ninja Math is an educational mobile game that has been developed by the Thinking Garden (www.thinkinggarden.com/). It is a physics puzzle game which is to test children's mathematics level. The game is available for Android and iOS platforms. The players must use their mathematics skill to beat each level (Figure 5 and Figure 6). Ninja Math is the latest

mobile game by Thinking Garden that combines fun, physics puzzle gameplay, and includes all of the basic arithmetic operators of mathematics such as addition (+), subtraction (-), multiplication (x), and division (/). Players able to switch any of the arithmetic operators on and off based on their knowledge level of mathematics. If the selected operator has been switched off, the related operator question will not appear in the mission. Otherwise, those operators will be mixed in 36 missions that appear in a non-linear style.

This game gives an added advantage to the parents who are willing to train mathematics skills to their children in an entertaining way. Besides that, players can choose difficulty level of gameplay such as easy, medium, and hard which each has different types of questions (such as the number involved in the questions are getting bigger from tens to hundreds). In short, when the difficulty level of game is getting harder, the questions are getting complex to solve.

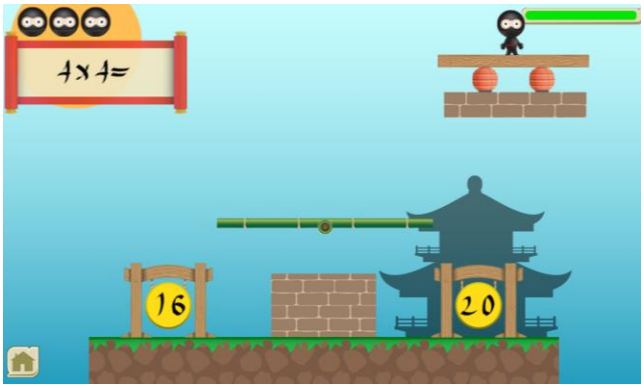

Figure 5 Ninja Math Game

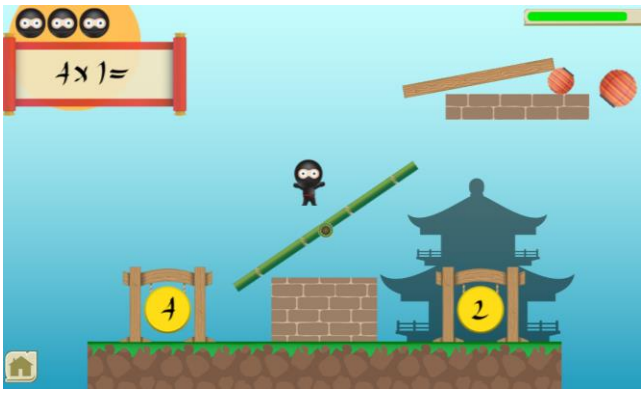

Figure 6 Ninja Math Game

4.0 TESTING COMPONENTS

A usability evaluation was conducted in order to find out how the users can easily and efficiently reach the application objectives. There are many usability evaluation methods; most were originally developed by Nielsen and Molich [17], and Nielsen [18]. In fact, the most utilized and useful usability heuristics was proposed by [19] and [20]. These heuristics however are more focused on the general applications and are not specific to games or mobile games. As noted in many literatures, Malone [21] has created the first heuristics for evaluating educational games. The problems that could be addressed here is none of these available methods being developed for evaluating mGBL, and these existing heuristics do not deal with mobility issues and do not cover learning content for evaluation.

Therefore, in evaluating the mGBL applications for this study, a set of testing components were utilized from Zaibon and Shiratuddin [16], adapted from Korhonen and Koivisto [22], by adding a new component that deals with learning content and context in mGBL. In particular, the heuristics evaluation strategy used in this study consists of four components: Game Usability (GU), Mobility (MO), Playability (PL), and Learning Content (LC). The testing ran in a natural setting while users play the mGBL which this has provided a better sense to users without having any formal circumstances. The next sub-sections describe these four testing components.

4.1 Game Usability (GU) Components

The GU components (Table 1) measure the interface and game controls aspects which the player interacts with the game. Game controls specify which types of keys and style of interactions that could be controlled by the users. In addition, game interface allows player to play smoothly and react based on user actions. In general, good game usability ensures that the player has interest to play the game until the end.

4.2 Mobility (MO) Components

Next, in Table 2, the MO components concern about the issues that affect mobility of the game. Mobility can be defined as the ease of a player to enter to the game world and the accessibility of the game from anywhere and at any time using mobile platform and interface. These components react accordingly to mobile technologies related to specific mobile features and functionalities.

4.3 Playability (PL) Components

The ten PL components (Table 3) test how the game is playable, run smoothly and consistently, meaningful, and not bored to player. The PL is important because it is dynamic and occurs when the player interacts with the game mechanics and rules.

4.4 Learning Content (LC) Components

Lastly, the LC components (Table 4) specifically concentrated on measuring the learning content. The learning content should provide informative, useful, and understandable content to users when playing the mGBL.

Table 1 Game usability components [22]

No.	Game Usability Components	Descriptions
GU1	Audio-visual representation supports the game	The games should look visually appealing. All graphics and audio should support game play and story; be consistent and informative to player.
GU2	Screen layout is efficient and visually pleasing	The screen design should present all necessary information to player and follow the general principles of good screen layout design.
GU3	Device user interface (UI) and game UI are used for their own purposes	The player interacts properly with the game user interface and device functions. Full-screen mode is preferable.
GU4	Navigation is consistent, logical, and minimalist	All buttons and navigations should be organized reasonably, provide more clarity and easier to remember. The navigation should also be intuitive and natural.
GU5	Control keys are consistent and follow standard conventions	Standard control keys can be used since the player already knows from other games they have played.
GU6	Game controls are convenient and flexible	The game controls are possible to be customized. The controls also should be designed based on device's capacities.
GU7	The game gives feedback on the player's actions	It is preferred if game user interface has a quick response on player's actions. The feedback can be presented in graphics, audio or tactile.
GU8	The player cannot make irreversible errors	The game should provide confirmation message for actions that can cause serious and permanent damage. Recovery is allowed when mistakes happen.
GU9	The player does not have to memorize things unnecessarily	The player's memory should be used at minimum. Game user interface design and challenges are considered in this aspect.
GU10	The game contains help	The game provides instructions to player for playing the game. It is unnecessary for player to read manuals frequently.

Table 2 Mobility components [22]

No.	Mobility Components	Descriptions
MO1	The game and play sessions can be started quickly	The game sessions can be started quickly and easily, preferably in less than five seconds. There is a possibility to skip the game introduction.
MO2	The game accommodates with the surroundings	Mobile games are played everywhere and this should accommodate the surroundings. The game audio volume can be conveniently adjusted or muted. The game should also put up with the device settings for instance, in silent mode.
MO3	Interruptions are handled reasonably	Interruptions such as incoming calls and messages are allowed during the play session. It is possible for the player to pause the game at any time and continue to play later.

Table 3 Playability components [22]

No.	Playability Components	Descriptions
PL1	The game provides clear goals or supports player created goals	The game goals are provided clearly because having a clear goal in player's mind is the core of an enjoyable experience. The goals can be either short-term or long-term.
PL2	The player sees the progress in the game and can compare the results	The game provides the game progress. The progress can be showed as high-score lists, rankings, character levels, or different titles.
PL3	The players are rewarded and rewards are meaningful	The game should provide rewards as a player progresses in the game. It should be meaningful for the player and should be adjusted to the challenge.
PL4	The player is in control	The player should know what is happening in the game world. The players will be able to decide on actions they have to take for continuing in the game world.
PL5	Challenge, strategy, and pace are in balance	The game should not bore the player and he can choose the difficulty level. All game strategies and the pace can be adjusted to the player's need.
PL6	The first-time experience is encouraging	The game can create a good first impression of the game within the first five minutes. The first play session should make the player desire for the next play session.
PL7	The game story supports the game play and is meaningful	The players can make their own decisions in the game. The story is meaningful and fits to the game elements.
PL8	There are no repetitive or boring tasks	The task repetitions without changing any conditions are not advised. This will give boring tasks to players.
PL9	The game does not stagnate	The player must know that the game progression and the game ending session should be clearly indicated. There is also a possibility of restarting the game again.
PL10	The game is consistent	The consistency in game world is important. The game actions, flow, and design should work in a consistent and logical way.

Table 4 Learning Content (LC) Components [16]

No.	Learning Content Components	Descriptions
LC1	The content can be learned easily	The game should provide an easy learning content, not too complicated as preferable for the intended users.
LC2	The game provides learning content	The game provides learning content, so that the users learn a new knowledge from the game. It could be any information that is of interest to the users.
LC3	The learning objective from the game is achieved	The learning objective from the game is achieved after the game ends.
LC4	The content is understandable	The learning content is easy to understand and as expected by the users.

5.0 METHOD

The testing sessions were conducted in Universiti Utara Malaysia which involved 20 users. Users were randomly selected and asked to play the three mGBL applications as described in the previous section. They played the three mGBL using the devices that were provided to them. The testing procedure was administered to users at suitable time where the times spent are recorded for each play session (Figure 7 and 8).

Figure 7 Respondents playing games during the testing.

Figure 8 Respondents filling in the testing form.

After the playing session was completed, they were given some brief instructions on how to complete the form. It was emphasized that form was remain anonymous, that is no 'right' or 'wrong' answer exist, and the users need to answer all questions with complete honesty. This testing will based on their perceptions towards each mGBL based on the components stated.

The questions were based on a scale of 3 points (1= does not meet need; 2 = adequately meets need; 3 = well meets need) and were tested on the four components of the heuristics evaluation strategy: game usability, game mobility, game play, and learning content (as described in Table 1 to 4). The scale was used to know whether each components are well met the requirements for the mGBL.

6.0 RESULTS AND DISCUSSION

In general findings, 12 respondents are female and the rest are male with the age ranged from 20 to 30 years old. Figure 9 reflects the frequency and Figure 10 shows the time spent of the participants playing mGBL.

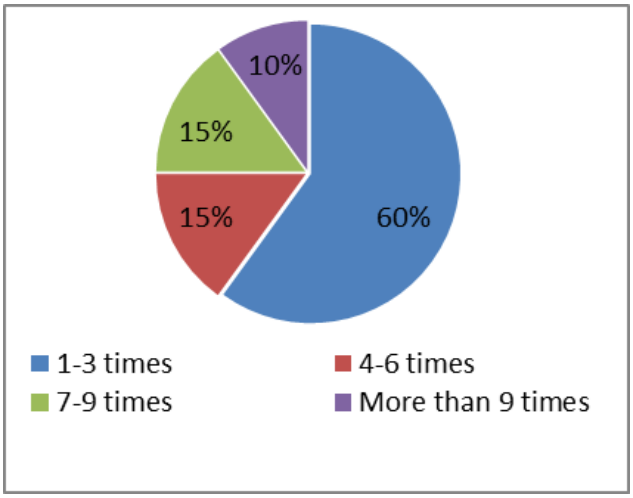

Figure 9 Frequency of playing mGBL in a day

60% of the respondents play mobile game for learning (mGBL) one to three times a day, and only 10% of them play mobile game more than nine times a day. From the result, it shows that all of the respondents play mobile game at least once a day. Every day they will play any types of mGBL with mostly less than one hour for each playing session. This result also indicates that mobile game is preferred to be played in less than one hour. Therefore, any mGBL should give players with a simple gameplay that could be played in a tiny time.

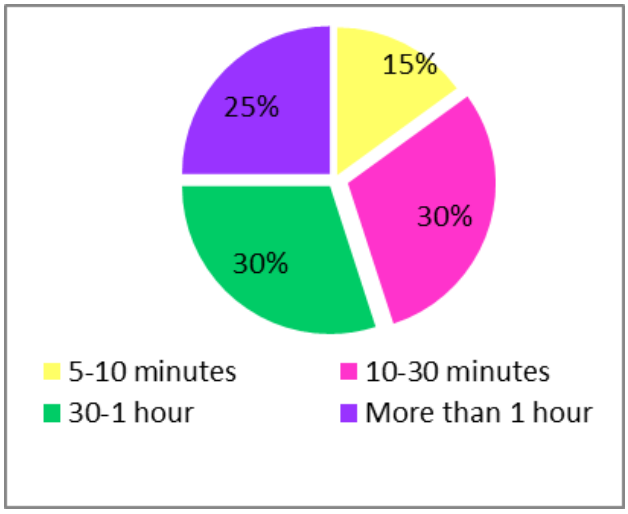

Figure 10 Time spent in a day playing mGBL

6.1 Game Usability (GU) Components

Figure 11 shows the comparison results in terms of "well meets need" for GU components between Ninja Math, Words, and Oh! My English mGBL applications.

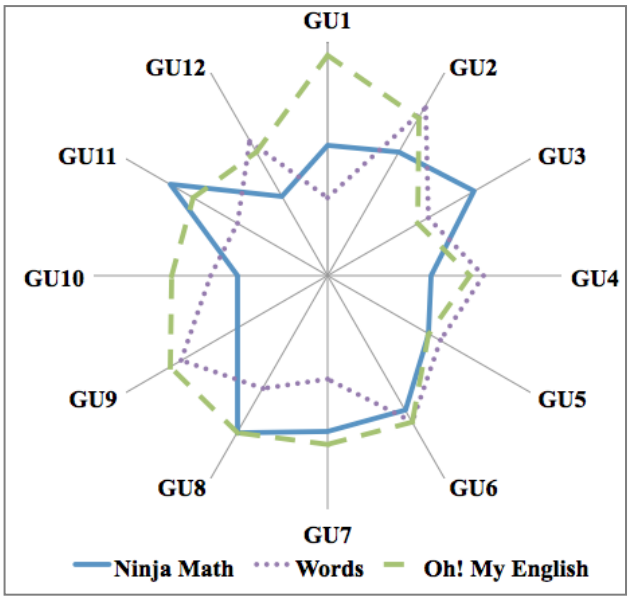

Figure 11 Game Usability Components

Oh! My English game is noted that its GU components are "well meet need" which has the highest score.

The highest component that meets need well is GU1 where audio-visual representation supports the game. Users feel that the game is seen visually appealing with all graphics and audio support game play and story; which also has consistent appearance and informative to them. However, Ninja Math and Words games have a similar patent of results. The results also show that all the three games score the lowest for GU5. This is related to the control keys which seems do not really consistent and follow standard conventions.

6.2 Mobility (MO) Components

In terms of mobility components (Figure 12), again the results show all of the components are "meets need well" for Oh! My English game. Unlike the other two games, the results give similar patent. This also means that most of the testers feel the Oh! My English game can be started to play quickly (MO1) and its mobile interruptions are handled reasonably (MO3).

This may relate to the persona of every tester who has their own thinking styles so it may influence their expectation to the mobile game. However for MO2, all the three games have similar results which indicate that the mobile games can be played everywhere and can accommodate the surroundings of the mobile environment. The game audio volume can be conveniently adjusted or muted. The game also put up with the device settings for instance, in silent mode. In conclusion, the mobility heuristics can be considered giving satisfaction the needs of testers. Most of the testers indicated the components has met need well of the game.

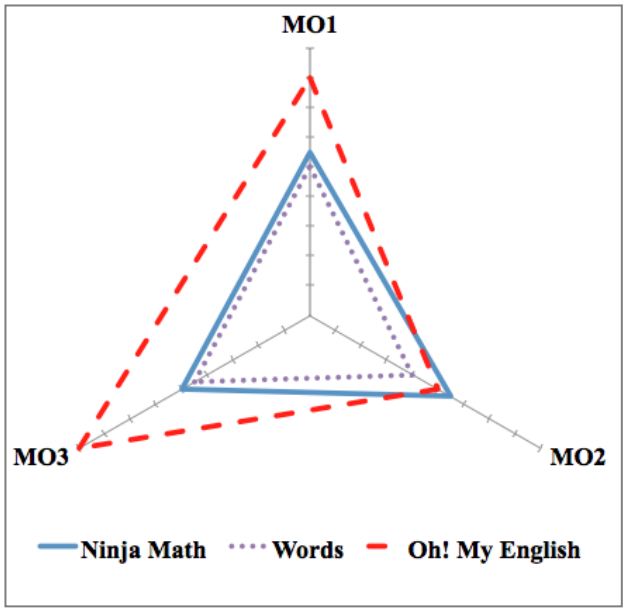

Figure 12 Mobility Component

6.3 Playability (PL) Components

In the component of playability (Figure 13), PL4 (the player is in control) have good scores for all the games which indicate that "they meet need well". The testers feel that they easily know what is happening in the game world. For example, in the Ninja Math, players can move the ninja character to the chosen answer by using their creativity, which means the players can express their idea when playing the game. PL10 (the game is consistent) also has the similar results for all the games. They feel that the games actions, flow, and design in a consistent and logical way.

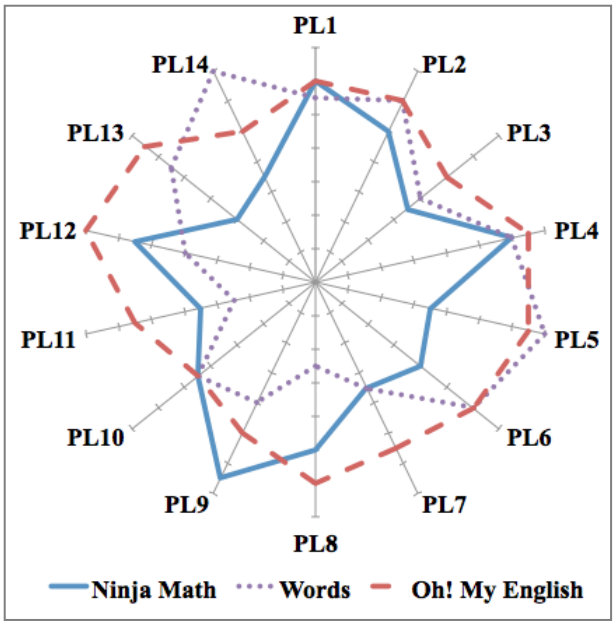

Figure 13 Playability Component

6.4 Learning Content (LC) Components

The component that is important for learning objective is the learning content component. The learning content components (Figure 14) are specifically concentrated on measuring the learning content of the game. In the components of learning content, all of the components get the highest vote for the components "meet the need well" for all games. The highest percentage for "well meets need" as agreed/scored by the respondents is the "learning objective from the game is achieved" (LC3) that scored 80%. However, in terms of the "game provides learning content" (LC2), the results are not consistent for all games. Although they are agree with learning content is provided, they think they do not learn the new knowledge from the games. This is because the testing was conducted to adults where the learning content of the games are developed for children. Although this is the case, the testing would know whether the learning content is well provided in the game.

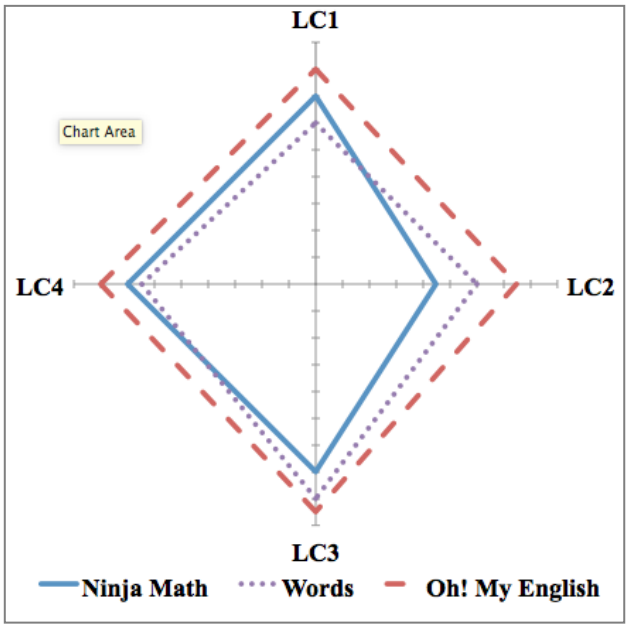

Figure 14 Learning Content Component

7.0 CONCLUSION

This study presents an approach to user testing of mGBL applications by adapting four testing components: Game Usability, Mobility, Playability, and Learning Content. These components are based on the quality of mGBL application which provide useful guideline to be followed and implemented by game developers.

The testing has been successfully conducted where 20 users were selected to play three different mGBL applications, and then they tested the game by completing testing forms. Users need to indicate whether each mGBL application is met the need for each testing components. The findings show that users successfully played and completed all testing forms. The study provides intensive review of mGBL characteristics that can be useful and may be of interest to game developers.

Prospective work could be recommended for this study, for example the study need to examine further on the learning impact based on learning outcome for intended users especially to the target users for each mGBL games.

In conclusion, the objective of this study to examine some mGBL applications using four testing components was successfully conducted. The results would provide enhanced testing mechanism for mGBL to mobile game designers and developers.

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References

[1] Sugar, S., and Sugar, K. 2002. *Primary Games: Experiential Learning Activities For Teaching Children K-8*. San Francisco: Jossey-Bass.

[2] Rieber, L. P. 1996. Seriously Considering Play: Designing Interactive Learning Environments Based On The Blending Of Microworlds, Simulations, And Games. *Educational Technology Research and Development*. 44(2): 43-58.

[3] Akilli, G. K., and Cagiltay, K. 2006. An Instructional Design/Development Model For The Creation Of Game-Like Learning Environments: The FIDGE Model. In M. Pivec (Ed.). *Affective and Emotional Aspects of Human-Computer Interaction: Game-Based and Innovative Learning* IOS Press. 93-112.

[4] Pachler, N. (Ed.). 2007. *Mobile Learning: Towards A Research Agenda. WLE Centre Occasional Papers In Work-Based Learning, Institute Of Education*. Technical Report 11. Retrieved Jan 22, 2008 from http://www.futurelab.org.uk/resources/documents/lit_reviews/Mobile_Review.pdf.

[5] Trifonova, A. 2003. *Mobile Learning-Review Of The Literature*. Technical Report DIT-03-009, Informatica e Telecomunicazioni, University of Trento.

[6] Mitchell, A., Inchingolo, P., Vatta, F., Gricar, J., Cisic, D., Petrovic, O., Kittl, C., and Peyha, H. J. 2006. Mobile Game-Based Learning To Promote Decision-Making Skills-A Pan-European Project. *The EURO mGOV Conference*.

[7] Pivec, M. 2005. *The Benefits Of Game-Based Learning*. [Online]. From: http://www.elearningeuropa.info/index.php?page=doc&doc_id=6456&doclng=3&lng=en. [Accessed on: Jan 22, 2008].

[8] Goodman, D., Bradley, N. L., Paras, B., Williamson, I. J., and Bizzochi, J. 2006. Video Gaming Promotes Concussion Knowledge Acquisition In Youth Hockey Players. *Journal of Adolescence*. 29(3): 351-360.

[9] Corti, K. 2006. *Games-Based Learning: A Serious Business Application*. [Online]. From: http://www.pixelearning.com/docs/games_basedlearning_pixelearning.pdf .[Accessed on: Jan 22, 2009].

[10] Sawyer, B., and Smith, R. 2008. *Serious Games Taxonomy*. Serious Games Initiative. [Online]. From: http://www.seriouagames.org/index2.html [Accessed on: December 15, 2010].

[11] Price, S., and Oliver, M. 2007. A Framework For Conceptualising The Impact Of Technology On Teaching And Learning. *Educational Technology and Society*. 10(1): 16-27.

[12] Sharples, M. 2009. *Methods For Evaluating Mobile Learning. Researching Mobile Learning: Frameworks, Tools and Research Designs.* Oxford: Peter Lang Publishing Group.

[13] Oliver, M., and Harvey, J. 2002. What Does Impact Mean In The Evaluation Of Learning Technology? *Educational Technology and Society*. 5(3).

[14] Vavoula, G., Sharples, M., Rudman, P., Meek, J., and Lonsdale, P. 2009. Myartspace: Design and Evaluation Of Support For Learning With Multimedia Phones Between Classrooms And Museums. *Computers & Education*. 53(2): 286-299.

[15] Ramos, A. J. 2008. *Project Mind: The Viability Of Mobile SMS Technologies For Non-Formal Distance Learning In Asia. Philippines*. Molave Development Foundation, Inc.

[16] Zaibon, S. B. and Shiratuddin, S. 2010. Mobile Game-Based Learning (mGBL): Application Development and Heuristics Evaluation Strategy. *Malaysian Journal of Learning and Instruction*. (7): 37-73.

[17] Nielsen, J., and Molich, R. 1990. Heuristic Evaluation Of User Interfaces. *Computer Human Interaction Conference*. 249-256.

[18] Nielsen, J. 1993. *Usability Engineering*. London: Academic Press.

[19] Nielsen, J. 1994. Enhancing the Explanatory Power Of Usability Heuristics. *Computer Human Interaction Conference*. 152-158.

[20] Muller, M. J., McClard, A., Bell, B., Dooley, S., Meiskey, L., Meskill, J. A., Sparks, R., and Tellam, D. 1995. Validating and Extension To Participatory Heuristic Evaluation: Quality Of Work And Quality Of Work Life. *Computer Human Interaction Conference*. 115-116.

[21] Malone, T. W. 1980. Heuristics for Designing Enjoyable User Interfaces: Lessons From Computer Games. *The 3rd ACM SIGSMALL Symposium and the first SIGPC Symposium*. 162-169.

[22] Korhonen, H., and Koivisto, E. M. I. 2006. Playability Heuristics For Mobile Games. *The 8th Conference On Human-Computer Interaction With Mobile Devices And Services*. ACM. 9-16. DOI: 10.1145/1152215.1152218.