The Psychological Aspects and Implementation of Adaptive Games for Mobile Application

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Abstract—**The mobile games industry and its development goals were not just for entertainment, but also used for educational of students interactively. Unfortunately the development of adaptive educational games that consider the psychological aspects for student on mobile platforms in Indonesian language that interesting and entertaining for learning process is very limited. This paper shows the research of development of novel adaptive games for students who can adjust the difficulty level of games based on the ability of the user, so that it can motivate students to continue to play these games. We propose a method where these games can adjust the level of difficulty, based on the assessment of the results of previous problems using neural networks with three inputs in the form of percentage correct, the speed of answer and interest mode of games (animation / lessons) to produce1 output. The experimental results are presented and show the adaptive games are running well on mobile devices based on BlackBerry platform.**

Keywords—**adaptive games, BlackBerry, Neural Networks**

I. INTRODUCTION

Your Nowadays, the application of games on mobile devices is growing rapidly and in great demand by students for entertainment or just increase their knowledge. Drastic increase occurred in the use of games for a fun and educational tool for students and effective discussion about the use of adaptive games to enhance interested learning and entertaining to various aspects of education [1][2]. The Net Generation [3] has already arrived at university and college. They differ completely from the people in charge of their education (their teachers and parents) in the role that ubiquitous technologies have played in their everyday lives.

Today, students have grown up using devices like computers, mobile phones, and video consoles for almost every activity, from studying and work to entertainment and communication. This has probably altered the way they perceive and interact with the environment, both physically and socially [4]. To meet the different cognitive requirements of the new generation, the educational community is considering new ways of learning. In particular, there is a wide interest in trying to engage students with the appealing features of videogames and Internet tools [5]. Computer games are an incredibly successful genre that captivates children as well as adults and that instantly mirrors the spirit of a time and the state-of-the-art in computer technology. Computer games combine art and technology in a fascinatingly natural and convincing way. The games' success is reflected in enormous sales figures, economic growth, and numbers of users [6].

Adaptive games-based learning style aims to support and encourage the learner considering his needs, strengths and weaknesses [16]. The best known of the games-based learning is to increases the motivation of learners [2] and the relationship between games and constructivist theory [6] because the games are well made can have pedagogical value of learning to produce a satisfactory outcome, because the student can cope with issues, work / play together and learn from previous experience. Technological pedagogical content knowledge is described as complex interaction of content, pedagogy and technology. The ways knowledge about tools and their pedagogical affordances, pedagogy, content, learners, and context are synthesized into an understanding of how particular topics that are difficult to be understood by learners, or difficult to be represented by teachers, can be transformed and taught more effectively with ICT, in ways that signify the added value of technology [14].

A crucial factor for adaptively is challenge. It can result from adapting the level of difficulty of the tasks to the learners' ability level so that a constant challenge is felt. Not only the level of difficulty of the tasks is adjusted to the learners' ability level, but also the system reacts to personal learning styles and preferences [16].There have been many studies on the development of education-based games for mobile applications such as [7]. But in the study, there is no comprehensive mechanism of how to identify the ability of users (students) who have a genuine interest in games or games that comes with a lessons and quizzes, as well as not using a Neural Network-based intelligence to input the percentage of correct answers, speed of answer and interest mode of games (animation /lessons). In addition, research on the development and use of adaptive educational games on mobile platforms in

Indonesian language for students has not been touched at all.

Educational game for mobile application is one tools of mobile learning. Learning, from constructivism point of view can be understood as achieving understanding through active discovery [18]. Learning is presented to allow progressive discovery of relevant concepts, in this case basic mathematical concept. This theory implied that student is an active learner. In order to create an effective mobile learning, learner need to initiate and be engaged in the game activity. According to [19], whether or not a game offers enjoyment to the player is a key factor in determining whether the player will became engage and continue to learn through the game. Situation of complete absorption or engagement in an activity is called flow experience [20]. Under this condition, one enter a state with these characteristics: focused and concentration, merging of action and awareness, loss of awareness of oneself, a sense that one is in control of one's action, distortion of temporal experience, experience of the activity as intrinsically rewarding[20]. Faiola, Newlon, Pfaff, Smyslova[21] found a significant correlation of flow experience and telepresence in virtual world (Second Life game). This finding suggest that learner who experience flow may acquire an improved attitude of learning online.

Being in the condition of flow is describe by subjective experience of engaging just manageable challenges by tackling a series of goals, continuously processing feedback about progress, and adjusting action based on this feedback[29]. In order to make a task that is just manageable, game designer should consider the ability that the learner already have. This theory implied to make an educational game that suit a particular group with particular level of proficiency. As Kukulsha-Hulme and Traxler [22] suggested, one of the prototypes for learning design exist based on knowing their progress and preferences as learners. In this case, the learners are 8-10 years old students. According to Piaget (1952) as cited in Santrock [23] students at the age 8-10 years old are at the concrete operational stage of cognitive development. They are able to predict space and time relationship, able to use map with concrete hints, able to differentiate concept in categories, and able to think logically. Therefore, they are able to do basic mathematical problems as in this education game application.

The proposed adaptive system using the method of identifying the profile and level of understanding of the material field of interest from the user contributes to a new method for adaptive games. Where the proposed model of educational games in the form of pure animation games and mathematics lessons/quiz based on artificial intelligence using Neural Network with 3 inputs and 1 output. The final result of this research is a framework of adaptive multiplayer game using neural network.

II. Neural Network for Adaptive Games

A. Neural Networks

As mobile games become more complex and consumers demand more sophisticated remote controlled opponents, game developers are required to place a greater emphasis on the artificial intelligence and multiplayer aspects of their games. Neural Networks are computational algorithms that mimic the way nerve cells work. The entire incoming signal is multiplied by the weights on each input, the neuron cells, all the signals are summed and then multiplied by the weight plus a bias. The sum is entered into a function (activation function) produces the output of the neuron (here used a linear activation function). During the learning process, the weights and bias are always updated using a learning algorithm if there are errors in the output.

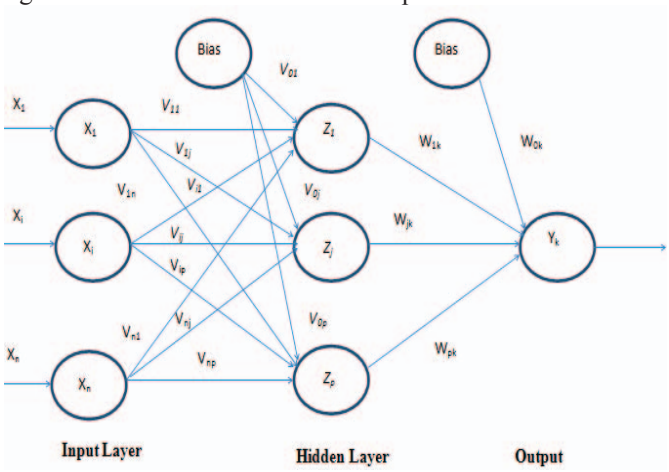

Figure 1. Neural network with 3 inputs and 1 output

Once modeling an artificial functional model from the biological neuron, we must take into account three basic components. First off, the synapses of the biological neuron are modeled as weights. Let's remember that the synapse of the biological neuron is the one which interconnects the neural network and gives the strength of the connection. For an artificial neuron, the weight is a number, and represents the synapse. Network is adjusted based on the comparison between the output and that output objectives in accordance with the target network. For the identification process, the weights are the direct weighing are called the input as a search parameter, as shown in Figure 1, the parameter is the price you are looking for w_1, w_2, w_3 and w_4. We use back propagation algorithm used for training the networks [11].

Based on figure 1, every input unit (x_i, $i = 1,\ldots, n$) receive the signal input x_i and forward it to all units in hidden layer. Each hidden unit (Z_j, $j = 1,\ldots,p$) summing the weighted input signal :

$$Z\_in_j = V_{ij} \quad (1)$$

Then we use the activation function to calculate the signal output, where the activation function is using binary sigmoid generally by the following formula:

$$f\left(z_{in_j}\right) = \frac{1}{1+e^{-z\_in_j}} \quad (2)$$

Every output unit (Y_k ,$_k$ = 1,..., m) calculate signal inputs :

$$Z\_in_j = V_{0j} + \sum_{i=1}^{n} X_i V_{ij} \quad (3)$$

Then using activation function to calculate the signal output :

$$Y_k = \text{f}(Y\_in_k) \quad (4)$$

Then using activation function to calculate the signal output :

PROPOSED METHOD

A. The Framework

Creating applications for mobile smart phone devices can be complicated by the following factors [15].

• *Screen size and Design*

Rich graphic elements and the information that can be viewed and managed at once are limited by small screens, requiring users to rely on short-term memory to build an understanding of an online information space. Only essential information should be displayed for this reason. Also, optimize necessary graphic elements to reduce file sizes and load times. The interface design must support the limited attention of users often distracted by people, events, activities, or objects. Mobile user interfaces should not have complex menus. Simple and descriptive pages and an ability to connect on-screen information with the physical world is desirable [16].

• *Input*

Text entries may be slow and susceptible to errors. Operating graphical user interface widgets (e.g., menus, hypertext links, buttons, scrolling, etc.) can be awkward. User control and efficiency can be enhanced by simple input and navigation schemes and by highlighting selected items.

• *Wireless Data-rate*

Wireless network connectivity on mobile devices may be limited in availability and bandwidth, which imposes significant restrictions on the amount and speed of interactions and rich media in networked applications. Moving to the next screen is often slower than dial-up Internet access. Mobile wireless systems, however, are achieving higher data rates to support internet and other data related applications. Soon fourth-generation systems will offer significantly higher data rates.

The process of designing the framework using a workflow of Software Development Life Cycle has been studied[12]. Figure 2 is our general framework shown using use case diagram that describe the actor and the important action in the games such as input name of the user, view high score, set the sound/voice, and playing with one/multiplayer.

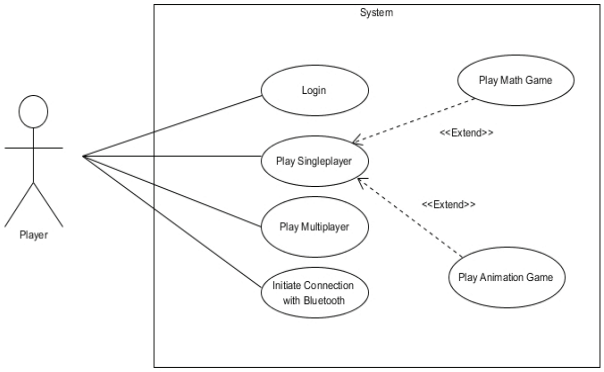

Figure 2. Usecase diagram for adaptive games

Theoretically, the building blocks for mobile games multiplayer framework consists of a non-visible game client component, a game server running on App Engine and utility classes in App Engine which perform web service calls and convert data between App Engine types and a format that is understandable to a server. Every application that uses the game server must include a game client component and use the method call blocks to make server requests.

Figure 3 shows the proposed class diagram for the adaptive multiplayer games. To store the data used by user, we use SQLite. SQLite is a software library that implements a self-contained, server less, zero-configuration, transactional SQL database engine with very fast games. SQLite is the most widely deployed SQL database engine for mobile games [17]. In figure 3, the Player, Device Blackberry and Database are the important entities in our system.

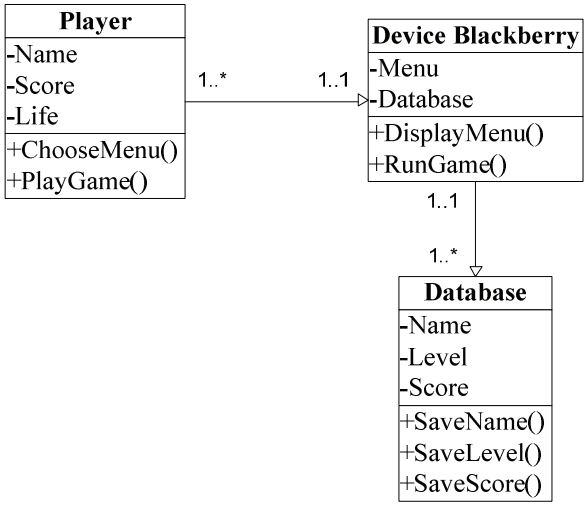

Figure 3. Class diagram of the adaptive games

The flowchart of how adaptive mobile games work is shown in Figure 4.

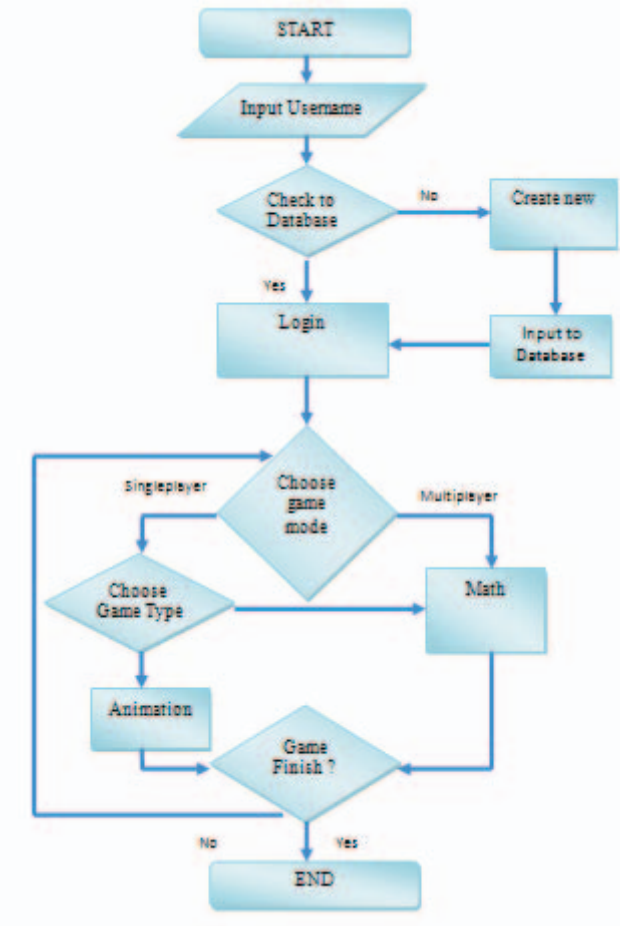

Figure 4. The flowchart of the adaptive games.

Figure 5 show the sequence diagram for adaptive games that have the ability for multiplayer using Bluetooth. Bluetooth® technology is a standard for short-range wireless technology. It enables two devices to communicate using radio waves that operate at 2.4 GHz. A BlackBerry® device that uses Bluetooth technology can open a wireless connection with other Bluetooth enabled devices, such as hands-free car kits or headsets that are within a 10 m range.

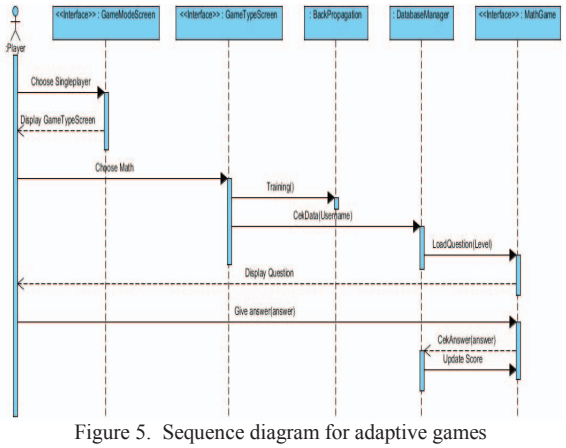

Figure 5. Sequence diagram for adaptive games

B. *Neural Network implementation*

The model of our neural network is designed for classification of the ability of users. The design of neural network is shown in figure 6 with 3 inputs x_1, x_2 and x_3 and output Y. Supervised learning is used in our model where the network is trained by providing it with input and matching output patterns.

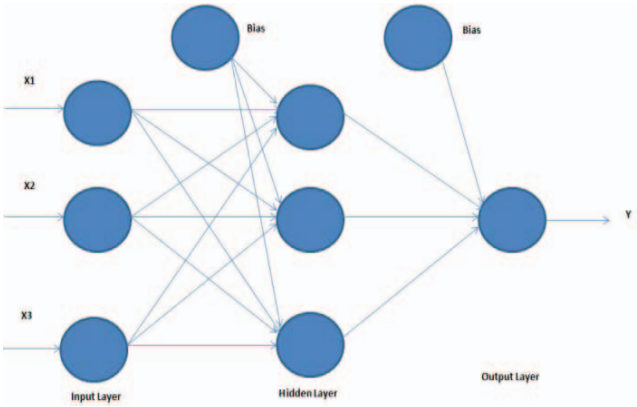

Figure 6. Neural Networks with output for classification for adaptive games

Explanation of input and output in Figure 6:
X_1: The time it takes the user to resolve questions.
X_2: Comparison between the frequency of correct answers and wrong.
X_3: Comparison of the frequency of the type of game played by the user (animation/math games).
Y: Adjustment of the level of difficulty based on the input.

For testing the neural network system, we use 8 training data and output. For example, if the user could not answer all of the questions in <=80percent time allowed, then x_1 is 0, if the correct answer <=80percent, then x_2 is 0. The output 0 denotes the next group of questions more easily, and if the output is 1 it indicates that the next game should be more difficult.

TABLE I.
TRAINING AND OUTPUT DATA USED IN THIS RESEARCH

Input			Output
X1	X2	X3	
0	0	0	0
1	0	0	0
0	1	0	0
0	0	1	0
1	1	0	1
1	0	1	1
0	1	1	1
1	1	1	1

EXPERIMENTAL RESULT

We have questionnaire for students and use 100 math questions for this experiment. Experiments performed on the Simulator and the real device BlackBerry Bold with OS 7.0 without lag and the results shown in figure 7. We have some mathematics questions for elementary until junior high school level, and some animation games such as "simple moving ball" and "Collecting bananas to basket" games to be choose by the user as shown in fig 7. For the mathematics and animation games, we set that the user/student said to be master if the correct result >=80 percent from 10 questions and time needed <=80% from the maximum time allowed. And if the user always chooses mathematics games for 3 times, then the default mode is set to the mathematics games mode.

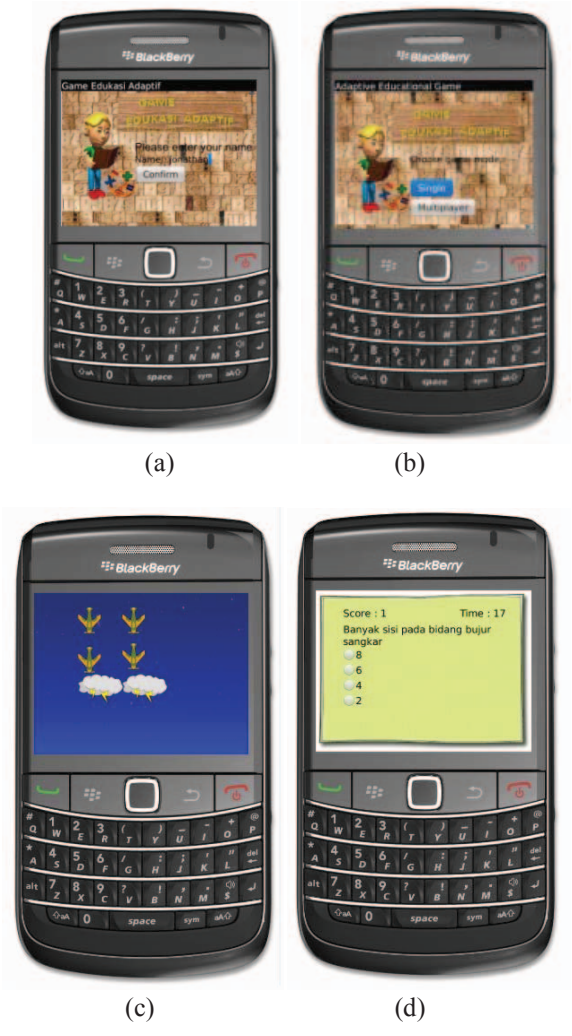

Figure 7. Result of simulation using BlackBerry Simulator, Main form for starting and choosing games animation/mathematics(a), questionin mathematics games (b) and example of ball games(c) and the best scorer stored in SQLite (d).

The training process does not require a long time, with the number of epoch determines the minimum error is obtained. Animation program created by the sound also can be run quickly. It should be noted that the handset is used must comply with the support of the OS used on the Development IDE used. Based on questionnaires and sampling that has been done to the 33 elementary school students as follows:

TABLE II. QUESTIONNAIRE ABOUT USING A MOBILE PHONE FOR PLAYING GAMES

Answer	Total	Percentage
Yes	33	100%
No	0	0%

TABLE III. QUESTIONNAIRE ABOUT HOW MANY TIMES A DAY FOR PLAYING GAMES

Answer	Total	Percentage
1	8	24%
2	12	36%
3	7	21%
4	2	6%
5	2	6%
6	1	6%

TABLE IV. QUESTIONNAIRE ABOUT TIME FOR PLAYING GAME

Answer	**Total**	**Percentage**
Morning	23	70%
Noon	3	9%
Evening	5	15%
Night	2	6%

TABLE V. QUESTIONNAIRE ABOUT TIME FOR PLAYING GAMES

Answer	Total	Percentage
< 30 minutes	1	3%
30 minutes	10	30%
> 30 minutes	22	67%

TABLE VI. QUESTIONNAIRE ABOUT HAVE EXPERIENCED DIFFICULTIES WHEN LEARNING MATHEMATICS

Answer	Total	Percentage
Yes	33	100%
No	0	0%

TABLE VII . QUESTIONNAIRE ABOUT INTERESTED IN LEARNING MATHEMATHICS USING GAMES

Answer	Total	Percentage
Yes	32	97%
No	1	3%

TABLE VIII. QUESTIONNAIRE ABOUT THIS GAMES ARE FUN

Answer	Total	Percentage
Yes	33	100%
No	0	0%

From the above it can be concluded that most gamers love a game because exciting, fun, challenging, and easy to play. Usually players more often play games in the morning for more than 30 minutes and accompanied by brother/sister. Almost all students interested in learning math using games or fun learning. Each student is confirmed to have tried adaptive games that have been made.

CONCLUSION

This research has developed a novel method for adaptive multiplayer games using the back propagation algorithm in neural network with 3 inputs and 1 output. The proposed adaptive system using the method of identifying the profile and level of understanding of the material field of interest from the user contributes to a new method for adaptive games. In addition, the training algorithm does not take much time so the time needed to start loading this game is quite fast. With a little training data, using the back propagation algorithm can handle noisy data and still be able to predict the correct output. In the epoch value of 10 is possible because the error falls off faster but it needs a longer time because the time needed per epoch longer because there are 10 nodes in the hidden units. On the other hand, the system trained neural network can also make decisions accurately and quickly. Almost all students interested in learning math using games or fun learning. Each student is confirmed to have tried adaptive games that have been made.Our adaptive games successfully achieve the goals to be played with multiplayer mode and able to identify the level of the user and adjust the difficulty level of the next animations/questions.

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REFERENCES

[1] W. Nicola,"Encouraging Engagement in Game Based Learning", *International Journal of Game-Based Learning*, vol. 1(1), pp. 75-84, 2011.

[2] C. Ming-Chun and Shyan-Ming Y. "An adaptive mobile application development framework", *Lecture Notes in Computer Science*, ***Springer Publisher***, Vol. 3824, pp. 765-774, 2005.

[3] D. Tapscott, Growing up digital: The rise of the net generation, New York: McGraw Hill, 1998.

[4] B. Timur and Tasar M. T., "In-Service Science Teachers' Technological Pedagogical Content Knowledge Confidences and Views about Technology-Rich Environments", *Center for Educational Policy Studies Journal*, vol. 1(4), pp. 11-25, 2011.

[5] M. Prensky, Digital natives' Digital immigrants. On the Horizon, 9 (5). 2001.

[6] S. de Freitas, Learning in immersive worlds. A review of game-based learning, 2006.

[7] Brusilovsky, P., & Maybury, M. T., From adaptive hypermedia to the adaptive web. *Communications of the ACM*, 45 (5), pp. 30-33, 2002.

[8] E. Brett, "Historical perspectives on games and education from the learning sciences", *International Journal of Game-Based Learning*, vol. 1(3), pp. 83-106, 2011.

[9] T. Glushkova, "Adaptive model for user knowledge in the e-learning system", *International Conference on Computer Systems and Technologies*, , pp. 161-166, 2008.

[10] K. Rob, Beginner BlackBerry Development, *Apress Publisher*, 2010.

[11] S. Haykin, Neural Networks and Learning Machines, 3rd ed., *Pearson Publisher*, 2008.

[12] R. Pressman, Software engineering: A practioner's approach. (7th edition), 2010.

[13] Kurkovsky, S., & Harihar, K. (2006). Using ubiquitous computing in interactive mobile marketing. Personal and Ubiquitous Computing, 10(4), 227-240.

[14] Kickmeier-Rust, M. D., Mattheiss, E., Steiner, C. M., & Albert, D. (2000). A Psycho-Pedagogical Framework for Multi-Adaptive Educational Games. Retrieved October 7, 2012, from http://www.eightydays.eu/Paper/Kickmeier%20Final.pdf

[15] D. Gavalas and D. Economou, "Development platforms for mobile applications: status and trends", *IEEE Software*, vol. 28, no. 1, pp. 77–86, jan 2011.

[16] Gasimov, C.-H. Tan, C. W. Phang, and J. Sutanto, "Visiting mobile application development: what, how and where", in Proceedings of the *International Conference on Mobile Business and Global Mobility Roundtable* (ICMB-GMR), Jun. 2010, pp. 74–81.

[17] SqlLite documentation, retrieved August 20th ,2012 from http://www.sqlite.org/

[18] Mayes, de Frietas, Learning and E-learning: The Role of Thepry, in Beetham, H., Sharpe, R. (Eds) *Rethinking Pedagogy for a Digital Age: Designing and Delivering e-learning*. London: Routledge, 2007.

[19] F. Ling Fu, R. Chang Su, S. Chin Yu, *EgameFlow: A scale to measure learners' enjoyment of e-learning games*. Computers & Educations, Vol. 52, 101-112, 2009.

[20] J. Nakamura, & Csikszentmihalyi, M., The concept of flow, in Snyder, C. R., Lopez, S. J. (Eds) *Handbook of Positive Psychology*, 89-105. New York: Oxford University Press, 2002.

[21] Faiola, A., Newlon, C., Pfaff, M., & Smyslova, O., Correlating the effects of flow and telepresence in virtual worlds: Enhancing our understanding of user behavior in game-based learning. *Computers in Human Behavior*, Vol. 29, 1113-1121, 2013.

[22] A. Kukulsha-Hulme, Traxler, J., *Designing for Mobile and Wireless Learning,* in Beetham, H., Sharpe, R. (Eds) Rethinking Pedagogy for a Digital Age: Designing and Delivering e-learning. London: Routledge, 2007.

[23] J. Santrock, W., *Life-Span Development.* New York: McGraw-Hill, 2011.

Top

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author Index

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