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Digital Game-based Learning: A Case Study of a Digital Educational Game in Hong Kong[1]

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Abstract: The objective of this paper is to examine how the use of digital games in education can be beneficial to learning, if not more successful than traditional learning. In May 2015, forty primary four to primary six (age ranged from 9 to 12 years old) local Hong Kong students were invited to take part in a case study, where the experimental group learnt and practised their compass and measurement skills by playing a digital game package, whereas the control group was taught compass bearings and distance measurement through a traditional math lesson. From the post-experiment survey and test performance, it was found that compared to the twenty students of the control group, the twenty game players of the experimental group showed more interest, curiosity, and motivation in the learning process. In this paper, we will first look into the results generated from the case study. Then, we will discuss how game players achieve positive results and become active learners in a stress-free learning environment. The

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potential and problems of gamification in the Hong Kong primary school setting will also be analyzed.

Keywords: Digital game-based learning (DGBL), mathematics education, self-directed learning, gamification

1. Introduction

According to the current *Mathematics Education Key Learning Area – Mathematics Curriculum Guide (P1 – P6)* (2000) published by the Education Bureau of the Hong Kong government, 'Measures and Space Dimensions' is one of the key learning areas for both Key Stage 1 (Primary one to three) and Key Stage 2 (Primary four to six). As indicated in the framework of learning objectives developed by the Education Bureau, by Key Stage 1, students need to learn how to identify the four directions (north, south, east and west) and get involved in various measuring activities. Then by Key Stage 2, students should be able to identify the eight compass points, use measuring tools, and handle simple problems in measurement:

Table 1. A summary of the key learning area, 'Measures and Space Dimensions' for Key Stage 1 and Key Stage 2.

Key Stage 1 (P1 – P3)	
1	To identify the four directions
2	To choose and use a variety of non-standard units to record results in basic measuring activities
3	To understand the need to use standard units of measurement
4	To select appropriate measuring tools and standard units of measurement
5	To integrate knowledge of Number, Measures, Shape & Space to solve simple problems in measurement
Key Stage 2 (P4 – P6)	
1	To identify the eight compass points
2	To choose and use a variety of non-standard and standard units to record results in various measuring activities
Key Stage 2 (P4 – P6)	
3	To select and justify appropriate measuring tools and standard units of measurement
4	To recognize the degree of accuracy and the approximate nature of

	measurement
5	To inquire and use simple measurement formulae
6	To integrate knowledge of Number, Measures, Shape & Space to formulate and solve simple problems in measurement

While the fundamentals of compass points can be taught with traditional teaching methods in the classroom setting, true navigation goes far beyond rudimentary concepts such as ‘north is always up’ and ‘the sun rises in the east’. Navigation is a crucial part of orienteering, which requires the combined skills of map reading, compass skills, distance measurement and pace. In order to master this key learning area, students will need to be able to visualize the directions and estimate the distance on maps. What is at issue is: visualization, the creative ability to imagine and mentally manipulate images and ideas, can neither be taught in class, nor through math drill and tests. It can only be acquired and realized through authentic or/and simulated orienteering experience. With little or no orienteering experience, many math students show weak understanding of concepts due to visual-spatial organization deficits. As Garnett (1998) points out, this is also one of the most common math learning problems that students of all ages encountered.

In light of this, the commissioned interactive educational project ‘The Mathematics iWorld’ was launched, and a free, open-for-all digital game package was developed to enhance the learning of measures, space dimensions and directions. Modeling situations from real-life orienteering scenarios, the e-learning game package is meant to be a user-centred edutainment device for self-directed learning outside the classroom. It aims to provide simulated orienteering experiences for primary school students, so that young learners can develop their visual-spatial skills on their own, while enjoying and engaging in the fun and challenging tasks in the game. Since 2002, the mathematics game package has been listed as ‘educational material’ in the Hong Kong Education City, the largest educational online portal in Hong Kong.

With a view to examining the effectiveness of incorporating digital educational games in mathematics education, a contrastive study on digital game-based learning and traditional-based learning of primary school students was conducted in May 2015. This paper will, by comparing the learners’ performance and learning motivation in both learning approaches, report on the key findings of the case study in Hong Kong, which will in turn reflect the potential and limitations of using electronic games for pedagogical purposes.

2. Digital Game-based Learning and Mathematics Education

Countless contemporary research studies have shown that the use of digital games, whether in formal or informal educational settings, was positively correlated with increased learning motivation and improved student mathematics achievement (Hubbard, 2000; Alagic, 2003; Hamilton, 2007; Ke, 2008; Park, 2008; Annetta et al., 2009; Carr, 2012; Rosen & Beck-Hill, 2012). However, digital games are not always educational, and digital educational games are not always effective. Below are three key features that an effective digital educational game should possess:

a. As in constructivist learning, the game should start with a challenging question, an interesting case, or an authentic scenario (Cooperstein & Kocevar-Weidinger, 2004). Rather than merely asking for factual recall and drill-and-practice, the game needs to simulate situations that will be encountered in real life, so that players can make meaningful choices (Baca, 2015). With clear goals to be accomplished, players can then learn by doing, learn from mistakes, get engaged in high-order thinking, building their problem-solving skills in a step-by-step fashion.

b. The game should encourage players to build new learning on prior knowledge. Winning should be based on conceptual understanding, connections between experience and new knowledge, and most of all, “application to real-world activities” (Pasquale, 2013, p. 52). While hints and feedback are given in response to each player’s attempt, the game setting should rule out the possibility of finding the right answer through random selection (Meletiou-Mavrotheris, 2012).

c. The game should either allow opportunities for collaboration or support competition among players. It should be set as a social activity that contributes to the development of the players’ social and emotional skills (Squire, 2005; Oblinger, 2004).

Despite the ever-changing learning environment, game’s content and design and learner variables, the three key features of effective digital educational games stay unchanged. In the following, we will introduce the design of the digital game, ‘Concepts and Measurement of Directions’, a web-based e-learning package for the Mathematics iWorld. We will also examine whether the digital game package can foster learning and promote intrinsic motivation of young learners.

3. Background of the Digital Game Package

To promote self-learning through the Internet, in 2000, the HKSAR Government established the Hong Kong Education City (www.hkedcity.net), an open e-learning platform under the Education Department. On this platform, various teaching and learning resources, including both private and public developed packages and tools, are provided. The digital game package was one of the projects created and developed for the Hong Kong Education City. It is a free learning resource kit for primary school teachers and students in Hong Kong in 2002.

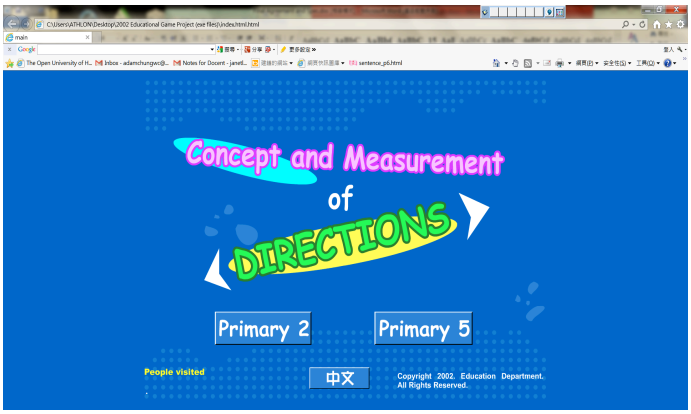
3.1. Aims of the Digital Game Package

Since the target users of the digital game package are primary school teachers and students in Hong Kong, the aims of the game package are:

- To promote the application of IT in mathematics education;
- To help students read locations on virtual maps;
- To strengthen students' knowledge of the four/eight compass points;
- To demonstrate compass skills with a virtual environment; and
- To teach the concepts of distance with virtual measurement.

3.2. Key Game Design Features

Illustration 1. Starting interface



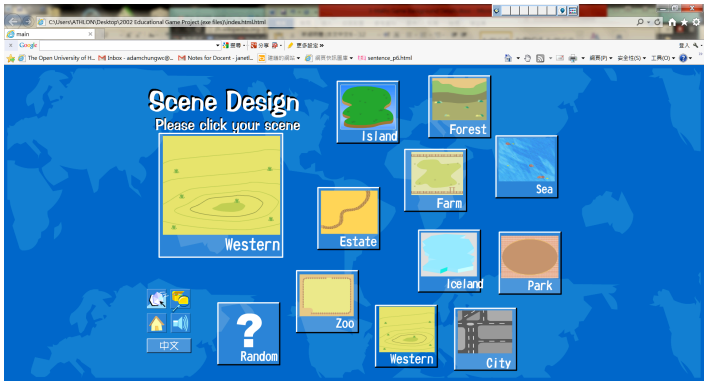
Since the primary target users are primary two (P.2) to primary five (P.5) students, the

interface design needs to be as user-friendly, interactive and attractive as possible to arouse users' interest. Animation and multi-media elements were created with easy and clear navigation tools. Multiple points of navigation and entry for opt-in and opt-out can be found on every page. To facilitate self-directed learning, all instructions were written in user-friendly and simple wording. Users of different levels can choose the language of instruction (Chinese or English), the level of difficulty, and the game type on the home page as they see fit.

Players can also choose to play the game individually or in pairs. The e-learning package includes three digital games, namely (A) 'Simulated Scene Design', (B) 'Direction Game', and (C) 'Treasure Hunting'.

In the first game, 'Sim Scene Design', the player is given ten scenes, which include a jungle, a park, a town, a business center, etc. This game allows the users to create their own scene(s) for teaching or playing, which provides an ideal setting that can actively engage the users.

Illustration 2. Scenes for selection in the scene design game



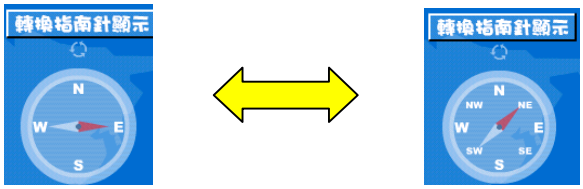
After a scene is selected, 15 relevant objects/locations are provided. The player can drag these items onto the selected scene.

Illustration 3. Scenes that can be chosen by the game player

Illustration 4. The chosen scenes can be dragged onto the virtual map.

A virtual compass is provided to measure directions from different locations set in the scene. The direction sign can be changed to a four or eight compass point. The compass pole can also be adjusted according to the player's need.

Illustration 5. The compass point can be set according to the player's level.

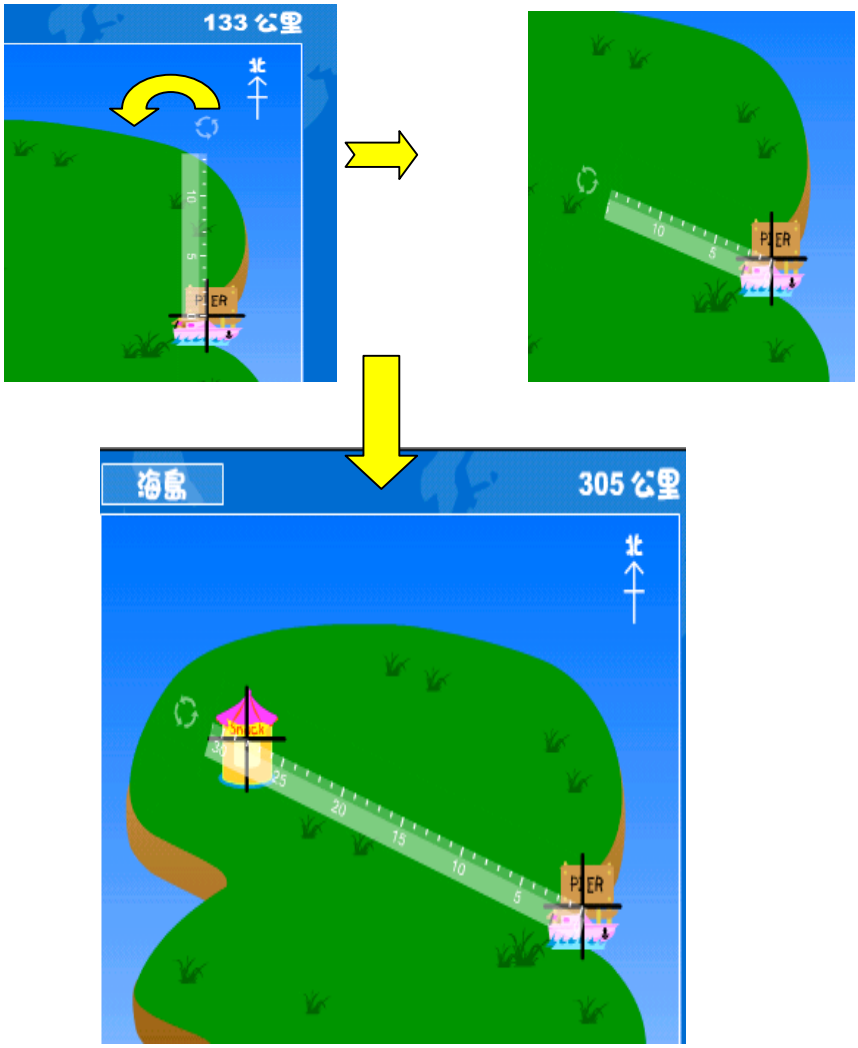


On top of the virtual compass, an extensible virtual ruler is given to measure the distance between two locations in the simulated scene. The extensible ruler can be rotated, lengthened, or shortened to measure the distance between two locations.

On the other hand, the second game, 'Direction Game', includes a set of interactive exercises that strengthen the player's knowledge and skills in map reading, compass bearing and distance measurement.

Last but not least, the third game, 'Treasure Hunt' was designed to arouse the users' interest and their learning motives. The game players can apply the mathematics skills acquired from the first two games and hunt for treasure. The rules and regulations of the game are summarized below:

Illustration 6. The extensible ruler for distance measurement on the virtual map



- The treasure hunt will take place on a 10x10 square chessboard;
- The chessboard will be filled with various obstacles and treasures;
- With the help of a compass, the player(s) will decide what step to take on the chessboard;
- Points will be granted to the player(s) each time a treasure item is achieved; and
- Players will be also awarded extra skills or magic (e.g. the power to change the compass direction, freeze time, take-away the other player's treasure box, etc.) after they finish the task.

4. Research Methods

To investigate the effectiveness of digital game-based learning in mathematics education, a control group and an experimental group were set in the case study. The control group consisted of a class of 20 local Hong Kong students studying P.4 to P.6, who were child members of the teens' reading club at the Tsuen Wan Public Library. 19 out of 20 of the control group participants revealed that they had learnt to identify the eight compass points from the math lessons in school. Nonetheless, in the study, a 20-minute traditional-based, face-to-face lecture on map reading, compass bearing, and distance measurement was given to the control group on 2 May 2015 (Sat). After the lecture, all control group participants were given a test on compass bearing and distance measurement. They were also asked to fill in a questionnaire and write down their feedback about the session after the test.

The experimental group, on the other hand, consisted of 20 local Hong Kong students who were junior members of the Scout Association of Hong Kong. 13 of the participants were P.4 to P.6 students, whereas 7 were P.3 students. Among the 20 experimental group participants, only 8 reported that they had learnt to identify the eight compass points from math lessons in school. 12 revealed that the topic of directions and distance measurement was new to them. On 17 May 2015 (Sun), the experimental group was first given a brief 15-minute lecture on map reading, compass bearing, and distance measurement. Then, each participant was given 5 minutes to try the digital game package. After playing the game(s), all experimental group participants were given a test, which tested their knowledge of compass bearing and distance measurement. Just as the control group, the experimental group was asked to fill in a questionnaire, writing down any remarks and comments they had about the session.

5. Findings and Analysis

5.1. Learning Motivation in the Control Group and the Experimental Group

As indicated in the questionnaires, up to 55% of the experimental group participants agreed that they found the digital game package helpful in strengthening their understanding of the key learning area of directions and distance measurement. 40% stated that the digital game package was effective to some extent. Moreover, 80% agreed that learning was enjoyable and engaging when digital games were incorporated. In the written feedback, the adjective "fun", "happy" and "interesting" occurred multiple times.

Table 2. A majority of the experimental group participants found digital game-based learning effective and enjoyable.

	Yes.	Yes, to some extent.	No.
1. Do you think the digital game-based learning session can help you understand compass directions and distance measurement better?	55% (11)	40% (8)	5% (1)
2. Do you think that the game-based learning session was enjoyable and engaging?	60% (12)	20% (4)	20% (4)

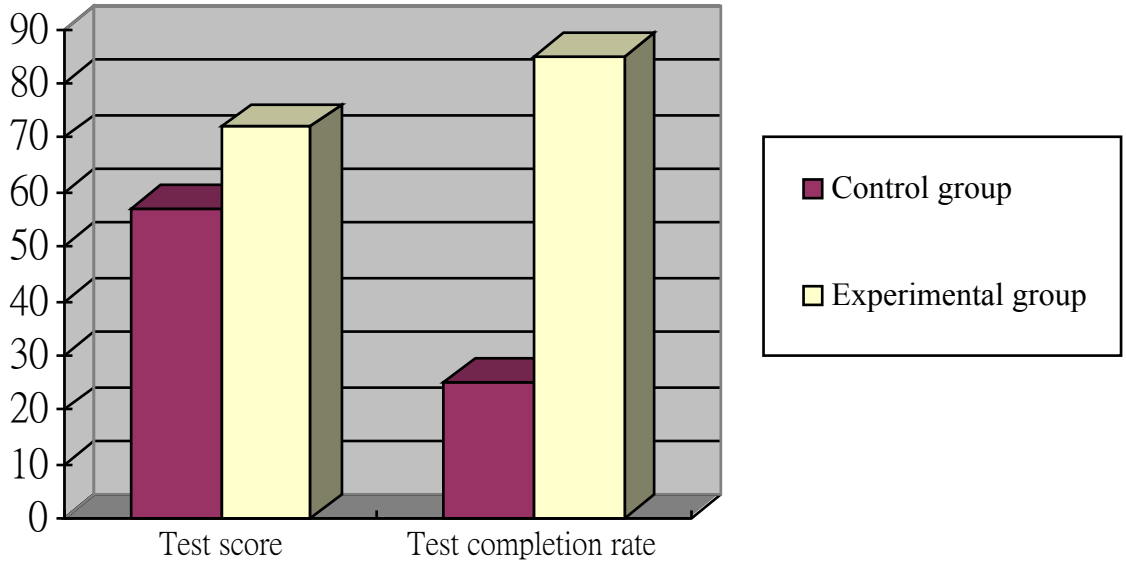
Yet, as shown in the survey data collected from the control group, only 40% of the participants replied that they found the traditional-based learning session enjoyable; 55% rated the session as “OK”; 25% reflected that the session could be improved if it could include games. Apparently, the digital game package did make learning fun for the experimental group. Digital game based learning can increase learner’s motivation.

5.2. Learners’ Performance in the Control Group and the Experimental Group

A positive correlation can also be noticed between the learners’ motivation and their performance. From the test results, it is shown that only 25% of the control group participants managed to complete all test questions, and the average score was 57 out of 100. The performance of the experimental group was found to be much better: 85% of the participants managed to complete all test questions, and the average score obtained was 72 out of 100.

Fig. 1. A comparison of the test score and test completion rate between the control and experimental groups

The data suggest that digital educational games can indeed enhance young learners’ motivation. Once motivated, learners tend to be more willing to spend time in learning, make an effort in completing challenging tasks, and eventually achieve better performance.



6. Challenges of Implementing Gamification into the Formal Curriculum

While the result of our small-scale research proves that digital educational games do enhance students' motivation and performance, in Hong Kong, digital educational games only hold a peripheral position in the school curriculum. To a certain extent, the implementation of digital games into the mainstream education system can be very challenging, and the challenges of using the DGBL approach have in turn made it less popular amongst teachers (Razak et al., 2012). The major difficulties in implementing gamification into the Hong Kong school curriculum are as follows:

a. Teachers are not game-designers. Not many teachers are ready to integrate digital games in their classroom. Few have been trained in the pedagogy of gaming in their teacher education programmes. As Gee (2009) notices, teachers, who are mostly digital immigrants, may need some time to learn and become more comfortable with digital games, game taxonomy, and game genres. Moreover, for most teachers, a good lesson is one designed with clear learning objectives that fit the curriculum. Unfortunately, most digital games, even the specifically designed ones, do not usually provide instructions for how they can be integrated with a curriculum. If teachers want to use digital games in the lesson, they will have to decide whether the goals of the games truly align with the learning objectives of the classroom. The readjustment of the curriculum to fit the game is a hard task. Thus, digital games

usually occur only in supplementary curricula rather than formal ones in the traditional classroom.

b. Formal assessment and evaluation such as examinations, oral presentations, and written assignments mean hard work. Students need to score high in public examinations and teachers are supposed to be the gatekeepers. The formal assessment and gate-keeping are of utmost importance in any education system, including the one in Hong Kong. However, by nature, game play is meant to be fun, free, and playful. Incorporating formal assessment into a digital educational game would defeat the primary purpose of the game itself. Since digital educational games cannot generate tangible results, they are often perceived as informal and time-consuming. This explains why gamification can only occur in a peripheral position in the formal curriculum.

c. Digital educational games do not extrinsically reward game players with high scores, high grades, or badges. Rather, they aim to get learners intrinsically motivated. Game players are supposed to genuinely enjoy the games and obtain intrinsic rewards such as happiness, a sense of accomplishment, and other positive feelings. However, what is fun for a certain group of learners may not be enjoyable for other learners. It is impossible to design a game that everyone finds fun and enjoyable. Moreover, different game players have different learning abilities. Even when they are playing the same game, each of them may be playing the game at a different pace on a different level. It is therefore difficult for teachers to use digital games in class, especially when the teachers are expected to prepare an equal amount of teaching materials for a class of 30 students within a fixed duration of time in a lesson, not to mention the tight class schedule that teachers need to follow.

d. The technical infrastructure of the school facilities (Routledge, 2009), as well as the accessibility to the digital games, can be an issue. Not all classrooms are fully equipped with computer devices and licensing that allow all students in class to play the same digital game at the same time during the lesson. It can also be hard for teachers to monitor the progress of students in class since digital games may not always allow teachers to inspect and evaluate the students' level of attainment, which varies from one person to another.

e. Parents' hesitant attitude towards digital game-based learning for children is another

big issue in Hong Kong. Most parents have reservation in the incorporation of digital games in classroom teaching. Many are worried that children can become addicted to playing digital games, which may affect their eyesight, communication skills, and social behavior. Among the many obstacles against the implementation of gamification in school, parental objections are the most challenging.

7. Conclusion

From the survey data, participants' written feedback, and the test results collected from this small-scale case study on mathematics education, we can conclude that the use of digital games for pedagogical purposes is not only useful in enhancing young learners' academic performance, but also powerful in making challenging topics such as measures and space dimension more engaging and enjoyable. Most noticeable of all, in the case study, all game players in the experimental group explored and learnt the rules of the digital game by themselves. No pre-game instructions were needed at all. It is thus undeniable that electronic games do bring educational benefits and help game players become autonomous learners. The value of play and the impact of digital game-based learning should not be overlooked. Although it may sometimes be difficult to implement gamification in the formal and conventional school setting, it is foreseeable that the new generation of digital natives would not be satisfied with the learning mode offered by the traditional education system. Integrating digital games into the mainstream curricula is an issue not just in Hong Kong, but in countries all over the world as well.

References

Alagic, M. (2003). Technology in the mathematics classroom: Conceptual orientation. *Journal of Computers in Mathematics & Science Teaching*, 22(4), 381-399.

Annetta, L. A., Minogue, J., Holmes. S. Y. and Cheng, M. T. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers & Education*, 53(1), 74-85.

Baca, A. (2015). *Computer Science in Sport: Research and Practice*. Oxon, U.K.: Routledge.

Carr, J. M. (2012). Does Math Achievement h'APP'en when iPads and Game-Based Learning are Incorporated into Fifth-Grade Mathematics Instruction? *Journal of Information Technology Education*, 11, 269 – 286.

Cooperstein, S. E. & Kocevar-Weidinger, E. (2004). Beyond Active Learning: A Constructivist Approach. *Reference Services Review*, 32(2), 141-148.

Garnett, K. (1998). Math learning disabilities. *LD Online.* Retrieved from www.ldonline.org/article/5896.

Gee, J. P. (2009). Welcome to our virtual worlds. *Educational Leadership*, 66(6), 48-52.

Hamilton, B. (2007). *It's elementary: Integrating technology in the primary grades*. Eugene, OR: International Society for Technology in Education.

Hubbard, L. (2000). Technology-based math curriculum. *T.H.E. Journal*, 28(3), 80-84.

Ke, F. F. (2008). A case study of computer gaming for math: Engaged learning from game play? *Computers & Education, 51*(4), 1609-1620.

---. (2009). A qualitative meta-Analysis of computer games as learning tools. In R. E. Ferdig (Ed.), *Handbook of research on Effective Electronic Gaming in Education*, New York: IGI Global, 1-32.

Meletiou-Mavrotheris, M. (2012). Game-enhanced mathematics learning for pre-service primary school teachers. *ICICTE 2012 Proceedings*, 455-465.

Oblinger, D. (2004) The next generation of educational engagement. *Journal of Interactive Media in Education*, *Special Issue on the Educational Semantic Web*, 8, 1-18.

Park, H. (2008). The impact of technology use on Hispanic students' mathematics achievement within family and school contexts: Subgroup analysis between English-and non-English speaking students. *Journal of Educational Computing Research*, 38(4), 453-468.

Pasquale, S. J. (2013). Education and learning theory. In Adam I. Levine, Samuel DeMaria Jr., Andrew D. Schwartz, Alan J. Sim. (Eds.). *The Comprehensive Textbook of Healthcare Simulation*. New York: Springer.

Razak, A. A., Connolly, T. M. & Hainey, T. (2012). Teachers' views on the approach of digital games-based learning within curriculum for excellence. *International Journal of Game-based Learning*, *2*(1), 33-51.

Rosen, Y. & Beck-Hill, D. (2012). Intertwining digital content and a one-to-one laptop environment in teaching and learning: Lessons from the time to know program. *Journal of Research on Technology in Education*, 44(3), 225-241.

Routledge, H. (2009). Game-based learning in the classroom and how it can work! In M.S. Thomas Connolly, Liz Boyle (Eds.), *Games-based Learning Advancements*

for Multi-sensory Human Computer Interfaces: Technique and Effective Practices. New York: IGI Global, 274-286.

Squire, K. (2005). Changing the game: What happens when video games enter the classroom? *Innovate: Journal of Online Education*, 1(6).