Chapter 13
An Explorative Study on the Pedagogical Potential of Gamification

Anna Wing Bo Tso and Janet Man Ying Lau

Abstract Recent studies indicate that learners who participate in digital game-based learning do exhibit a deeper understanding of the learned subject, better problem-solving skills, and a higher level of academic achievement. However, to what extent can educational games be adapted to the local context, culture, and curriculum is yet to be examined. With a view to finding out how useful digital gamification is to young learners, this chapter recounts a small-scale study on the pedagogical possibility of electronic gaming in the Hong Kong mathematics curriculum and then progresses to a discussion of how digital game-based learning can increase learners' motivation, develop learners' autonomy, and improve their academic performance.

Keywords Digital game-based learning (DGBL) · Gamification · Primary school mathematics education · Self-directed learning

The Learning Landscape in the Digital Age

According to Bloom's taxonomy of learning domains (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956), educational objectives can be classified into hierarchical categories, each progressing into the next. The successive levels of knowledge structure are ordered from less to more complex in the following sequence: knowledge, comprehension, application, analysis, synthesis, and evaluation. Similarly, in Anderson and Krathwohl's modified taxonomy of the cognitive domain (2001), there are six successive levels: remembering, understanding, applying, analysing, evaluating, and creating. When educators compare the conventional classroom teaching with the taxonomy of learning domains, it is found that because of the

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numerous constraints in the class size, time limitation, and assessment standardisation, learning in classrooms can hardly go beyond the knowledge stage of rote memorisation and defining.

The issue of classroom teaching and learning is getting more and more problematic as technologies proliferate in recent years. For the twenty-first-century digital era, educators and researchers have come up with new taxonomies of what learners should obtain in education, which includes digital literacy, team-working, problem-solving, self-directed learning, and readiness for lifelong learning (Jerald, 2009; Voogt & Roblin, 2012). The conventional teaching mode in classrooms falls short in facilitating most of the new skills mentioned in the new taxonomies of learning domains, and it is imperative that educators promote digital gamification, or digital game-based learning, which not only trains up learners' digital literacy but also 'recruit[s] learning and mastery as a form of pleasure' (Gee, 2008, p. 36), helping learners 'to develop situated understandings, to learn through failure, and to develop identities as expert problem solvers' (Squire, 2006, p. 26).

Purpose of the Study

While edutainment through digital games has opened up new possibilities in teaching (Buckingham, 2005; Gee, 2003; Prensky, 2002), some teachers and parents in Hong Kong are still hesitant to accept the game-based e-learning approach. One major concern is: gameplay can be an addictive time waster. If digital educational games are to be adapted to the formal curriculum, to what extent can they really enhance students' learning experience? With a view to exploring the effectiveness of incorporating electronic educational games in the formal curriculum, in May 2015, we conducted a contrastive study of the conventional lecture method and the gamification teaching method in primary mathematics education in Hong Kong.

Research Questions

In our preliminary study, we have two research questions:

1. Can digital gamification increase learners' motivation and autonomy when young learners (aged 8–11) learn serious mathematics items such as compass skills, map reading, and distance measurement?
2. Can the use of digital games improve the young learners' math performance?

By comparing the learners' performance and learning motivation in both pedagogical approaches, we will first report on the key findings of the case study in Hong Kong. Based on the data and results, we will discuss the pedagogical potential of digital gamification.

The E-Learning Game Package

This digital game package was one of the free resource kits created and developed for the Hong Kong Education City, established by the HKSAR Government (www.hkedcity.net) as an open e-learning platform under the Education Bureau. The target users of the digital game package are primary school teachers and students in Hong Kong. Learning materials, games, and quizzes in different subjects can be found in the website, which range from languages to science.

The digital game package, ‘Concepts and Measurement of Directions’, is a web-based e-learning package for the Mathematics iWorld of the Hong Kong Education City. It includes three digital games, namely, (A) ‘Simulated Scene Design’, (B) ‘Quiz’, and (C) ‘Treasure Hunt’. Each game is designed with a specific learning aim to enhance the players’ knowledge on the concepts and measurement of directions. The digital game package is intended to provide students’ learning motives to explore the games themselves. As children love playing games, using games as the learning tool is appropriate. The design of the game flow and interface has employed a user-friendly navigation strategy. Active engagement, interactivity, and visually attractiveness in the game design are meant to suit the needs of children at the age of 7–11 (i.e. Primary 2 to Primary 5), who are also the primary target group.

In consideration of user-friendly navigation, all instructions were written in simple expressions and the texts are easy to scan in an online environment. As shown in Figs. 13.1 and 13.2, the clear button design assists players of different education levels. Players can choose the language of instruction (Chinese or English) and the game type as they see fit. The games also allow players to opt in and opt out anytime with multiple points of navigation and entry on every page. It is designed particularly to aid the classroom teaching environment that is not necessarily bound by time or sequence. It provides freedom for players to change pathways. The games can be played individually or in pairs.

To achieve self-directed learning, children players have to actively engage in the gameplay. In other words, interactivity and visually attractiveness are essential elements in children games. Additionally, the story setting in the game is another important component that can enhance interactions among the players in the gameplay. Although linear storytelling in game design is a common approach, this game package is not quite the same. It does not have a strong narrative or a linear storytelling to follow through from one point to another. Instead, the game structure offers various settings allowing users to create their own individual ‘mini-story’. For example, as Fig. 13.3 has shown, in game (A) ‘Simulated Scene Design’, the player is given ten scenes, including a jungle, a park, a town, a business centre, etc. After a scene is selected, 15 relevant objects/locations are provided and five objects in maximum can be selected (see Fig. 13.4). The player can drag these items onto the selected scene (see Fig. 13.5). The idea of this digital game is like giving a choice of several objects for players to create their own scene. After the objects are dragged onto the virtual map of the selected scene, players will need to answer the questions

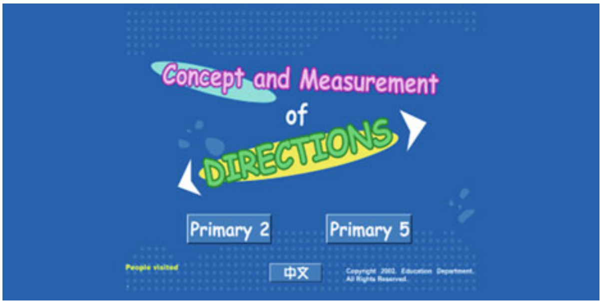

Fig. 13.1 Homepage where game players can choose the language and the educational level

Fig. 13.2 Page where game players can choose from the three different digital games (they can play the digital games in any order as they wish)

Fig. 13.3 Page where game player can choose the scenes

Fig. 13.4 Page where game players can drag the selected items onto the virtual map of the selected scene

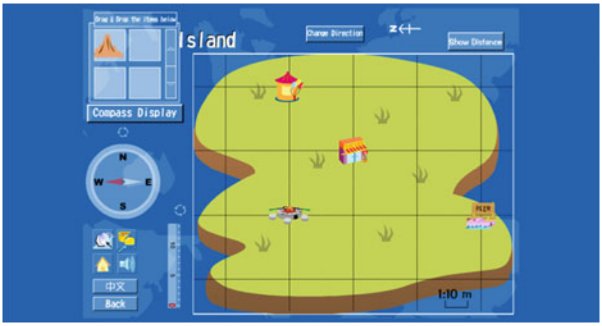

Fig. 13.5 Page where game players can play the selected items in any location they prefer within the virtual map of the selected scene

in relation to the direction of the chosen object with the use of compass point and the extensible ruler provided in the game. It encourages the players to participate in and work creatively through learning. Players are expected to get actively involved in designing their own individual ‘mini-story’ and enjoy learning through playing.

To further enhance the players’ learning experience, the other two games, (B) ‘Quiz’ (Direction Game) and (C) ‘Treasure Hunt’, are designed for players to apply their knowledge and skills in map-reading, compass bearing, and distance measurement. The former includes a set of interactive exercises as revision for student players (see Fig. 13.6), while the latter allows player(s) to apply the mathematics skills acquired from the first two games and hunt for treasure. The latter game, as shown in Fig. 13.7, is designed in a chessboard-like format, and the player (s) need to enter the direction and steps in order to move the designated cartoon character(s). Each move is given a controlled time. Player(s) need to obtain as many treasures as possible and escape from the barriers to win the game. The ‘Treasure Hunt’ game provides a competitive environment which keeps the player(s) more engaged in the game.

Methodology

In order to gain a better understanding of how electronic games may influence the learning and teaching of primary mathematics education, we conducted a small-scale case study by setting a control group and an experimental group. Both groups consisted of a class of 20 local Hong Kong primary school students aged 8–11. Ninety-five percent of the control group participants revealed that they had learnt to identify the eight compass points from the math lessons in school. On the other hand, only 40% of the experimental group participants had learnt about compass directions. Nonetheless, in the study, a 20-min conventional-based, face-to-face lecture on map-reading, compass bearing, and distance measurement was given to the control group. Likewise, the experimental group was given a similar 15-min lecture. The only difference was that on top of the lecture, each participant of the experimental group was also given 5 min to play the electronic game package. Finally, all

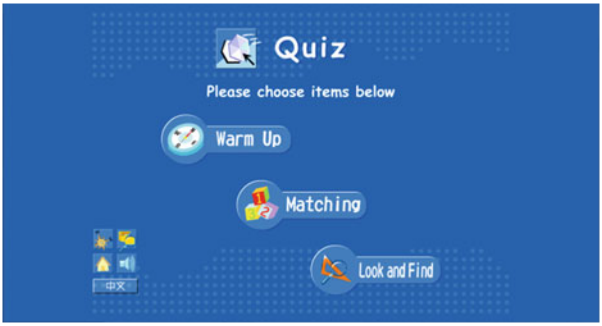

Fig. 13.6 Three types of interactive exercises to be chosen

Fig. 13.7 A two-player chessboard game

participants were given a test on compass bearing and distance measurement. After the test, all participants were asked to fill in a questionnaire and write down their feedback about the learning session too.

Findings and Discussion

The survey data show that up to 95% of the game players in the experimental group acknowledged the effectiveness of electronic games in mathematics education, among which 55% stated that electronic educational games were helpful in strengthening their understanding of compass directions and distance measurement; 40% agreed that the electronic game package was, to some extent, useful.

Learners' Motivation and Autonomy in the Control Group and the Experimental Group

Noticeably, as can be seen in Table 13.1, 80% of the game players reflected that learning became exciting and engaging when they were allowed to try the new

Table 13.1 The views towards the electronic games of the experimental group participants

	Yes	Yes, to an extent	No
1. Do you think electronic games can enhance your understanding of compass directions and distance measurement?	55% (11)	40% (8)	5% (1)
2. Do you think that the learning session with electronic games was enjoyable and engaging?	60% (12)	20% (4)	20% (4)

electronic games in the learning session. As we instructed the game players to stop playing the game and move on to the math test, many participants asked if they could be allowed more time to continue with the game. Many participants who had completed the written test also came back and requested if they could play the electronic games again. From the written feedback, it is found that young learners from the experimental group used positive adjectives such as 'fun', 'happy', 'useful', and 'interesting' to describe their learning process.

However, the survey data collected from the control group do not appear to be as positive as that of the experimental group. Although 19 out of 20 participants agreed that the lecture on compass directions and distance measurement was useful to them, only fewer than half of the participants replied that they found the conventional-based learning session enjoyable; 11 rated the session as 'passable' only, whereas one-fourth of the learners proposed that the session could be improved if games are used (see Table 13.2).

Apparently, game-based learning is desirable for all. The control group suggested that games should be used in their learning, while the experimental group reflected that the digital game package did make learning enjoyable for them. Through the small-scale case study, we can see that electronic games, when incorporated in mathematics education, can definitely increase learners' motivation and autonomy.

Math Performances in the Control Group and the Experimental Group

Comparing the test performances of the control group and experimental group, we can observe that there may be a positive correlation between learners' performances and the use of electronic educational games. Most noticeably, as can be seen from Figs. 13.8 and 13.9, our data show that only 25% of the control group participants managed to complete all test questions, and the average score seems unexpectedly low: only 57 out of 100. Moreover, while most control group participants gained score through rote memorisation in *Part A: Labelling the compass points*, they performed fairly poorly in *Part B: Distance measurement on the map*.

By contrast, the performance of the experimental group was better in all aspects: as shown in Figs. 13.1 and 13.2, 85% of the participants completed all test questions. The average score obtained was 72 out of 100, and most experimental group

Table 13.2 Feedback from control group participants on being asked 'How do you think the learning can be improved?'

1	Game. Game is fun
2	Play games; go out of the classroom
3	Through the games
4	Through the games
5	Give harder questions; explain more

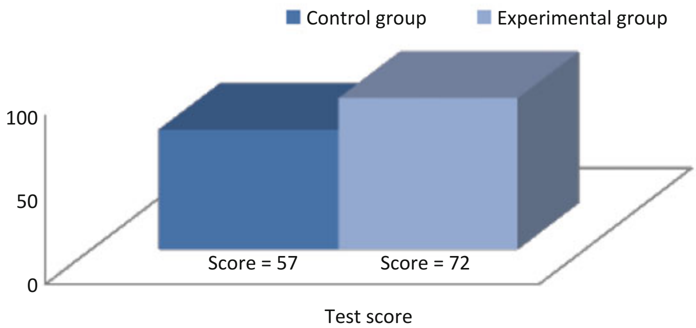

Fig. 13.8 A comparison of the test score of the control and experimental groups

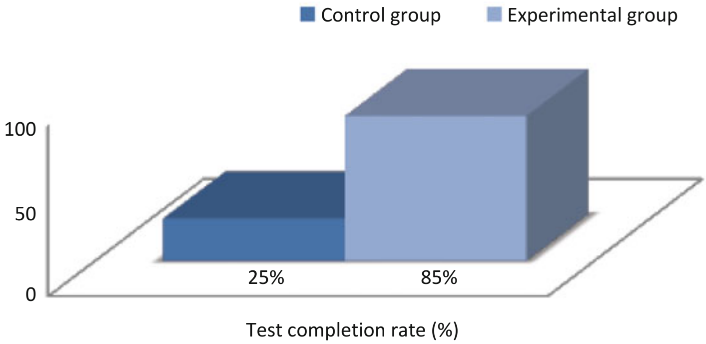

Fig. 13.9 A comparison of the test completion rate of the control and experimental groups

participants gained relatively good scores from both *Parts A* and *B* of the test. This shows that most learners of the experimental group not only had good rote-memorisation skills but also better map-reading, compass, and distance measurement skills.

The results suggest that electronic educational games can indeed create a positive chain reaction in learning: first, they enhance young learners' motivation, turning them in self-directed learners. Once motivated, learners tend to be more willing to spend time in learning and make an effort in completing challenging tasks. As a result, it comes as no surprise that the highly motivated, hard-working self-learners achieve better learning results and a higher level of satisfaction.

Conclusion

Through the survey statistics, participants' feedback, and the test results collected from this small-scale case study, we can conclude that the use of electronic games for learning and teaching in primary mathematics education is successful. It is not only useful in eliciting learners' motivation, enhancing learner's self-directed learning skills, but also significant in improving learners' academic performance. As digital experience has come to play a central role in modern life, educators should reflect upon what they can do to help students train up their digital literacy, problem-solving, self-directed learning, and readiness for lifelong learning, so as to become competitive and well-equipped for their future. The conventional teacher-centred method must change. Incorporating game-based e-learning in classrooms is going to be a global trend.

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