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Designing and evaluating a mobile educational game "Void Broken 2.0" for history instruction

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Abstract: This study adopted Theory of Cognitive Development in the design of an educational game for Chinese history learning, Void Broken 2.0©. An empirical study was conducted to explore whether this game can help students improve their history learning performance and have good evaluation results. Sixty-six high school students (24 boys and 42 girls) participated in this study with an average of 16.26 years old. The results showed that the student's history learning performance improved significantly after playing the game and the mean scores of game evaluation in all dimensions were above the median. Although male students perceived the game as more useful and easier to use compared to female students, the history learning performance and the evaluation of the game elements showed no significant of gender differences.

Keywords: game-based learning, theory of cognitive development, history instructions

1. Introduction

Traditional history instructions usually focus on memorizing names and date. Therefore, many students consider history a boring subject unrelated to their lives, resulting in their low learning motivation (Schul, 2015). For example, there are a large number of events and figures during the turbulent period of modern Chinese history (A.D. 1644-1911). Their names and relations are difficult to memorize for students, but they are necessary for Chinese history learning. Without enough background knowledge, students may have difficulties in history learning (Monem, Bennett, & Barbetta, 2018; Okolo, 2005). Moreover, students should develop their inquiry skills to analyze complicated ancient documents (Shanahan, Bolz, Cribb, Goldman, Heppeler, & Manderino, 2016).

On the other hand, one of the advantages of traditional history instructions is the efficient reorganization of historical contents and materials (Schul, 2015). Some researchers believe that students interacting with teaching materials actively have better learning performance (Monem, Bennett, & Barbetta, 2018). Therefore, if we add game elements (Prensky, & Thiagarajan, 2001; Alessi, & Trollip, 2000) to help students easily interact with the learning materials, they may be more interested in the analyzing process of historical data. The process of human knowledge development is explained by Piaget (Piaget & Cook, 1952), which can be the foundation for the learning material design. According to Piaget, a cognitive schema is the basic unit of human memory, which changes or reforms through the adaptation process. The adaptation process includes assimilation, accommodation, and equilibrium components.

This study intends to integrate cognitive schema, assimilation, accommodation, and equilibrium components into an educational game for Qing dynasty history learning, Void Broken 2.0. In the game design, the cognitive schema includes the main elements of the game, the relations among characters, and the historical events during that period; the adaptation process includes the mechanism for information match and acquisition. The students are expected to acquire history knowledge efficiently by analyzing and inquiring plenty of historical data in this game.

1.1 Research Questions

This study has three research questions investigating whether Void Broken 2.0 helps students improve their history learning performance and whether the students enjoy their learning process. The educational game-based learning design also should consider gender differences (Lukosch, Kurapati, Groen, & Verbraeck, 2017). Therefore, we also explore whether this game is suitable for students of different genders.

Do students have a better history learning performance after playing Void Broken 2.0?
Do students show high evaluations for the game after playing Void Broken 2.0?
Is there any effect of gender differences on students' history learning performance or game evaluation after the students play Void Broken 2.0?

2. Methodology

2.1 Participants

The sampling method of this study was convenience sampling. From the researcher's lecture classes, the participants were freshmen of high school in northern Taiwan. The average age of the participants was 16.26, including 24 boys (36%) and 42 girls (64%). The total number of the participants was 66 and they never took the formal courses about the content in this experiment. Before the day of the experiment, students were divided into a group of two or three students, and there were 32 groups in total.

2.2 Research Design and Procedure

In this study, a single group pretest design (pre-experimental design) was used, and the same experiment was performed in two classes. Each experiment began with a 10-minute pretest, and then the researcher explained the game for 10 minutes. Each group also received a book with game instructions. After the students understood the game mechanism, they played the game for 50 minutes without the novice guide. Subsequently, the students were given a 10-minute posttest and a 10-minute game evaluation questionnaire (Figure 1). The experiment took about 90 minutes in total. The game was played by the same group student members, while the pretest, posttest, and the game evaluation questionnaire were completed by each individual student.

The game system was preloaded into 8-inch mobile devices, which could be applied to the general traditional teaching environment without network. During the experiment, each group of the students received a mobile device with the opening scene of the game on the screen. The researchers only helped the students with technical problems that were not related to game contents, e.g., the game quit unexpectedly. The students could only discuss with other members from the same group rather than with the members from different groups during the gameplay. Except for the gameplay stage, each individual student completed all the tests and the questionnaire by himself or herself and could not look for any data or discuss with others.

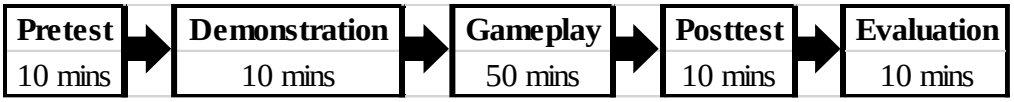

Figure 1. Procedure of the experiment.

2.3 Educational Game for History Learning: Void Broken 2.0

This study used HTML5 as the development tool and modified the Void Broken, which had been created in 2016. The new version was called Void Broken 2.0, with its game mechanism and core gameplay adjusted based on the learning theory. We also added more historical information and pictures to connect the learning theory with the game mechanism and learning materials. The game was completed in 2017. The game story was about a time-space traveler, who accidentally returned to the ancient Chinese Qing Dynasty. The student played the traveler to match the correct figures and events. By using a special device, students could conquer all the battles and go back to reality.

According to the curriculum guidelines of domestic high school, the historical data was designed by the researcher, a high school history teacher. Because of the limited experimental time, the experimental version of the game only included five historical events and three difficulties, but the original number of 50 historical figures remained unchanged.

2.3.1 Cognitive Development Theory and Game Mechanisms

The figures and events in this game were designed as the fundamental units for players to memorize and acquire. Realizing the relations among them was necessary for history learning, and the players needed to match the correct relations in the game.

The students were expected to experience the adaptation process during this relation matching. For instance, when the students played the game at the beginning, they may already notice certain incorrect relations among characters and events, leading to the difficulties in battles. The student players could not get to the next challenge if the match was few correct. The students' cognitive schema that the incorrect relations did not work in battles and needed to be fixed for the next challenge led to the students' accommodation. After some trials and errors, the students may find out that they needed more descriptions of the relations and they could acquire the information from the historical data in the game. The students' cognitive schema changed and reformed when they were acquiring new knowledge, which was called assimilation. After the students went through all the challenges without difficulties, they were skilled in matching and their cognitive schema worked without errors. This was called equilibrium, which was the result of our expectation.

Table 1

Components of Cognitive Development Theory

Components	Players' Behaviors
Cognitive Schema	Realizing characters, events, and their relations The researchers used characters, events, and their relations as the pretest and posttest.
Adaptation Processes	Matching characters to events based on their relations It is a process for players to connect characters and events.
Accommodation	Feeling difficult to match the relations between characters and events The students' cognitive schema needed to be fixed for the next challenge.
Assimilation	Acquiring information about events, characters, and their relations The students' cognitive schema changed when they were acquiring new knowledge.
Equilibrium	Feeling easy to match the relations between characters and events The students were skilled in matching and their cognitive schema worked without errors.

2.3.2 Characters, Events and Relations

In this study, fifty important figures of the Qing Dynasty (A.D. 1644-1911) were designed as in-game decks. The important five historical events were designed as game battles (Figure 2), which were Taiping Kingdom of Heaven, Self-Strengthening Movement, First Sino-Japanese War, Nien Rebellion, and Siege of the International Legations. Each battle had three difficulty levels, depending on the number of cards, the accuracy of pairing requirements, the level of guardian monsters, and the number of rounds, etc.

There were two kinds of relations in the game. One was the characters' identities and the other was the relations among characters and events. The characters' identities referred to the statuses of historical figures in the Qing Dynasty. There were four statuses, including Royal Family, Political Minister, General Military, Foreign Forces or Anti-Government Elements. For instance, Empress Dowager Cixi was classified as a royal family because of the pedigree of the ruling nation and the highest predominant class. Hong Xiuquan was classified as an anti-government element because he led The God Worship armed group to carry out military activities against the Qing government.

The relations among figures and events included whether the figure's lifetime span was across the event period (called contemporary) or not (called irrelevance), or the person had an important influence on the event directly (called participant). For example, Hong Xiuquan was born in 1814 and died in 1864. The event of the Taiping Kingdom of Heaven occurred between 1851 and 1864. Hong Xiuquan was the leader of the God Worship armed group and led the troops to take over Nanjing (an important city at that time in southern China). Consequently, the relation between Hong Xiuquan and the Taiping Kingdom of Heaven was seen as a participant.

The event of the Nien Rebellion occurred between 1853 and 1868, which overlapped part of Hong Xiuquan's lifetime span, but he did not make a significant impact on this event in history. The relation between Hong Xiuquan and the Nien Rebellion was considered contemporary. Other people whose life span did not overlap the event were named as an irrelevance.

Figure 2. The main interface of Void Broken 2.0.

2.3.3 Matching Mechanisms

Matching is a process for players to connect characters and events. Players placed the cards in hand on the 3X3 grid battle board (Figure 3), and the system calculated the score according to the correct relations between the characters and the events. The final score in the round equaled the power against the guardian monster.

The vertical line on the battle board was the position to check the relations among the cards and the battle, which was called the timeline condition. The horizontal row was the position to test the identity of the cards, which was called the status condition. Any position would test both conditions at the same time. If a player placed a card on the battle board, but no condition was activated, the card was going to break.

To encourage the players to challenge the accuracy of more conditions, we designed a bonus frame, which was only activated by dual conditions and appeared on the battle board randomly. The number of bonus frame was one or two, depending on the difficulty level of the battle. It is a necessary skill for the students to get into the next level because of the high health point of guardian monsters and the limited rounds. When the players were getting familiar with the characters and events, they were able to activate more conditions and had more opportunities to overcome the challenges.

In addition, we also hoped that students can learn more from matching, so the cards on the battle were different without repetition every round. The cards on the battle were based on the deck built by the players before the battle. The deck needed eight or sixteen cards, depending on the difficulty level. At the easiest level, the players had to build eight cards into their deck with three cards in hand every

round. At the other difficulty levels, the players had to build sixteen cards into the deck with five cards in hand every round.

This design helped the players to understand a certain number of characters; otherwise, they may lose the battle because of some unfamiliar cards. This design also encouraged the players to master the relations and to use more cards, so that the students could learn more things as their prior knowledge in history.

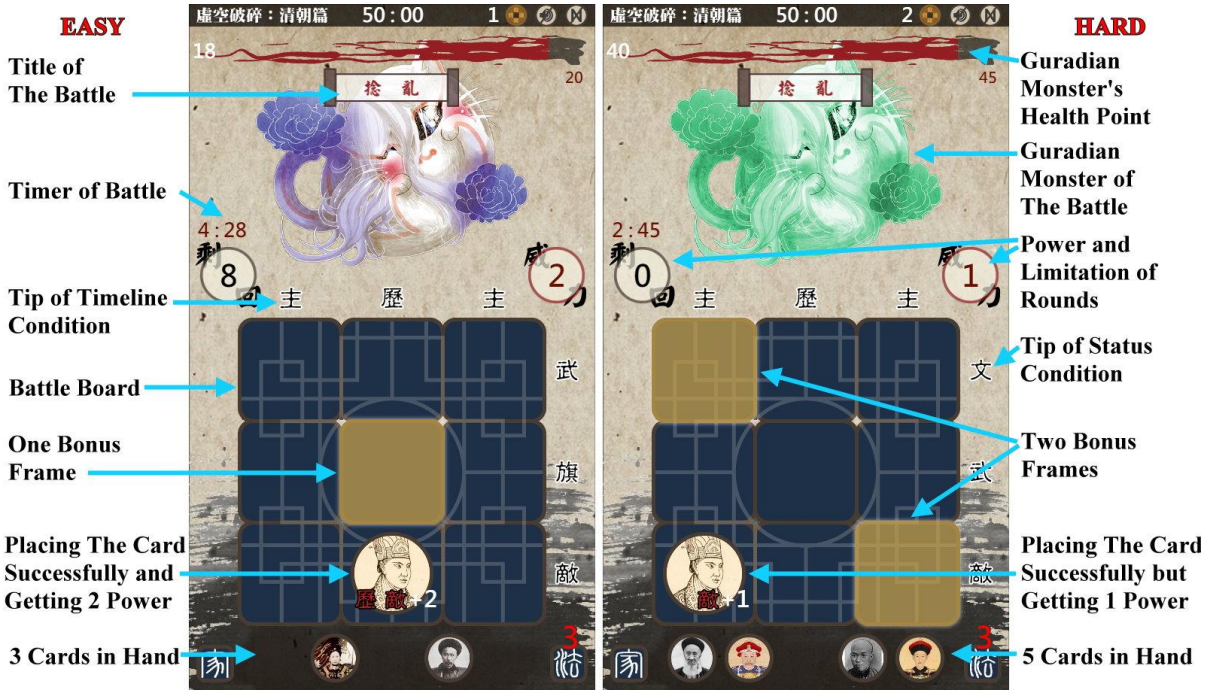

Figure 3. The battle interface of Void Broken 2.0.

2.3.4 Acquired Information Mechanisms

The battles designed in this study was based on the location of historical events in the ancient Chinese map of the Qing Dynasty (Figure 2). Players started a battle by clicking the title of events on the map. The students could read the biography of characters and the description of events in the game (Figure 4).

Figure 4. The information of events and characters.

The biography of characters contained the name, picture, lifetime and a brief introduction. Players could decide the suitable cards for certain battles based on the clues in the biography. The description of the events included the title, picture, and descriptive information. Players could decide the event for their deck based on the clues in the descriptions. The players were expected to have high learning motivation and reform their cognitive schema by analyzing those historical data in the game.

2.4 History Learning Performance Evaluation

The history learning performance evaluation was developed by the researchers to test students' history learning performance after they played the game. The researchers used participants' relation matching items as the pretest and posttest. There were five events and 50 figures in the game. The students should answer the number of figures in each event in the limited answer slots. The total score of the evaluation was 48 points and each correct answer received one point. The topics of the pretest and posttest were exactly the same. In order to reduce the memory effect of students, the order of events in the pretest and posttest was different, but the number of figures remained the same.

2.5 Game Evaluation Questionnaire

This study used the game evaluation questionnaire of Hou and Chou, (2011) and made a slight modification according to the need of this study to evaluate the game system. The questionnaire was a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=agree and disagree are equal, 4=agree, and 5=strongly agree). It investigated the perceived usefulness, perceived ease of use (Davis, 1989), and game elements evaluation (Prensky, & Thiagarajan, 2001; Alessi, & Trollip, 2000) by the students. The internal consistency was .90 (Cronbach's α = .899). In 2012, Chou et al. (Chou, Hou, Yu, Lee, Wu, Yang, & Liao, 2012) used the same evaluation questionnaire with the reliability of .783, which was considered acceptable by DeVillis (1991).

3. Data Analysis and Results

3.1 History Learning Performance

The first research question in this study investigates whether the students have better history learning performance after playing Void Broken 2.0. We conducted a dependent sample t-test on the history learning performance with the students' pretest and posttest scores. As shown in Table 2, the student's history learning performance improved significantly after the game ($p<.001$, $t=9.58$). This finding may suggest that the students acquired more knowledge about the relations among characters and events after the gameplay. The results showed that the average score of the students' progress was 5.74 points (the maximum progress score in the sample was 18 points). This indicated that the students could answer correctly more than 5 items after the 50-minute gameplay.

Table 2

The Paired-Samples t Test of History Learning Performance

	Posttest (N=66)		Pretest (N=66)			
	M	SD	M	SD	*t*	*p*
History Learning Performance	13.62	5.66	7.88	4.38	9.58***	.000

*** $p < .001$

3.2 *Game Evaluation Questionnaire*

The second research question investigates the students' evaluations of the game. According to the game evaluation questionnaire, the results showed that the means in all dimensions were above the median (median=3), as shown in Table 3. This finding suggests that the game was perceived useful in history learning and not difficult to play. In addition, the students were satisfied with the game elements

designed in the game. Generally speaking, this result indicates that the game designed in this study is an enjoyable history educational game.

Table 3

The Mean and Standard Deviation of Game Evaluation Questionnaire

Dimensions	M	SD
Overall Game Evaluation	4.29	0.53
Perceived Usefulness	4.29	0.58
Perceived Ease of Use	4.14	0.70
Game Elements	4.41	0.63

3.3 *Gender Differences*

The third research question investigates whether the gender factor affects the students' history learning performance and game evaluation. According to the results shown in Table 4, gender differences were not found in students' history learning performance but found in the overall game evaluation. In more depth, the effect of gender was found in the two dimensions of the students' game evaluation (perceived usefulness, and perceived ease of use). Compared to female students, male students believed that the educational game was more helpful in their learning, and it was easier to use.

Table 4

The Independent-Samples t Test of History Learning Performance and Game Evaluation between Gender Groups

	Male (N=24)		Female (N=42)			
	M	SD	M	SD	*t*	*p*
History Learning Performance	4.21	4.10	6.62	5.10	-1.98	.052
Overall Game Evaluation	4.49	0.49	4.18	0.53	2.35*	.022
Perceived Usefulness	4.54	0.51	4.14	0.57	2.83**	.006
Perceived Ease of Use	4.38	0.68	4.01	0.69	2.09*	.041
Game Elements	4.52	0.65	4.35	0.61	1.10	.276

* $p < .05$, ** $p < .01$

4. Discussion, Conclusion and Future Works

Based on the findings in this study, we believe that the Void Broken 2.0 can help students learn more about modern Chinese history of Qian Dynasty. From the results of history learning performance, the students can understand more important figures in history. When playing the game, the students can discuss, explore, and analyze historical materials with their team members. This group work may help improve their knowledge acquisition process and could be practiced in the history classroom.

According to the results of high scores in the game evaluation, it seems that the students enjoy the game. This information also indicates that we can bring students back to the classroom and focus on learning. The teacher doesn't have to talk much and the students can focus on the game. From the experience of the researchers in the experimental field, the students are very active and don't feel that they are taking part in a boring history class. Many students want to play the full version of the game in the future.

However, we are also worried about whether such a design is biased to certain game groups. In terms of gender differences, it seems that the game was viewed as more useful and easier to use by male students. It is probably because male students are more familiar with game designs and operations. However, the students' history learning performance and the game elements evaluation are not

significantly different between male and female students. This suggests the game can be useful and enjoyable for students' learning regardless of their genders.

Based on the findings in this study, it seems that the game may improve the students' history learning performance and enhance their learning motivation. However, whether the students' high-level cognitive process can be facilitated by the game remains unknown in this study. We are also curious about the collaboration and problem-solving process of students in the game. For future studies, it may be necessary to integrate other methods for data triangulation. For example, researchers can analyze the students' high-level cognitive behaviors with the system operation records and the discussion data of the students. This may help explain the students' high-order cognitive thinking process (Hou, Yu, Chiang, Lin, Chang, & Kuo, 2019) and related issues.

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References

Alessi, S. M., & Trollip, S. R. (2000). *Multimedia for learning: Methods and development.* Allyn & Bacon, Inc..

Chou, Y. S., Hou, H. T., Yu, M. C., Lee, H. J., Wu, H. S., Yang, Y. T., & Liao, Y. J. (2012, March). Running Tommy©: Developing a Digital Adventure Game Based on Situated Learning to Promote Learners' Concepts of Earthquake Escape. In *2012 IEEE Fourth International Conference On Digital Game And Intelligent Toy Enhanced Learning* (pp. 156-158). IEEE.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

DeVillis, R. F. (1991). *Scale development: Theory and applications.*

Hou, H. T., & Chou, Y. S. (2011). Designing a Digital Adventure Game Integrating Instant Feedbacks with Simulation Manipulation to Promote Learners' Knowledge of Computer Hardware. In *Work-in-Progress Poster of the International Conference on Computers in Education: ICCE 2011* (p. 41).

Hou, H. T., Yu, T. F., Chiang, F. D., Lin, Y. H., Chang, K. E., & Kuo, C. C. (2019). Development and Evaluation of a Mind tool-based Blog Learning Environment for promoting learners higher order Cognitive thinking in online Discussion activities: Analysis of Learning Effects and Cognitive Process, *Journal of Educational Computing Research.*

Lukosch, H., Kurapati, S., Groen, D., & Verbraeck, A. (2017). Gender and Cultural Differences in Game-Based Learning Experiences. *Electronic Journal of e-Learning, 15*(4), 310-319.

Monem, R., Bennett, K. D., & Barbetta, P. M. (2018). The Effects of Low-Tech and High-Tech Active Student Responding Strategies during History Instruction for Students with SLD. *Learning Disabilities: A Contemporary Journal*, 16(1), 87-106.

Okolo, C. M. (2005). Technology and social studies instruction for students with mild disabilities. *Handbook of special education technology research and practice*, 623-641.

Piaget, J., & Cook, M. (1952). *The origins of intelligence in children* (Vol. 8, No. 5, p. 18). New York: International Universities Press.

Prensky, M., & Thiagarajan, S. (2001). Digital Game-Based Learning, Paragon House, St. *Paul, Minnesota, USA.*

Schul, J. E. (2015). Pedagogical triangulation: The mergence of three traditions in history instruction. *The Social Studies*, *106*(1), 24-31.

Shanahan, C., Bolz, M. J., Cribb, G., Goldman, S. R., Heppeler, J., & Manderino, M. (2016). Deepening what it means to read (and write) like a historian: Progressions of instruction across a school year in an eleventh grade US history class. *The History Teacher*, *49*(2), 241-270.