Designing a web-based drill game to improve learners' resources classification abilities: A case study

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Abstract: There is still limited research investigated the effectiveness of and mental aspects toward web-based drill games on learning resources classification. The purpose of this study was to design a web-based drill game "Happy Black-faced Spoonbill", to improve learners' resources classification abilities. Content analysis was used to investigate each aspect of motivation, attention, perceived ease of use, and perceived usefulness toward the game owned by students from the interview data. Twelve students of grade 4 to 6 who were randomly selected from a cram school were volunteered in this study to play the game. The findings showed that the drill game could be useful in helping learners to acquire and practice the targeted content knowledge. In addition, providing features of fun, points, and rewards were deemed as important and attractive in game design for obtaining learners' attention and targeted learning outcomes. The game with ease of use and usefulness features could also facilitate students to improve their learning performance, increase their knowledge acquisition, and experience more effective learning.

Key words: Web-based drill games, motivation, attention, ease of use, usefulness.

Introduction

Recently, with prosperous technology, researchers have been interested in the possibilities that game brought to the learning environment [1, 2]. For instance, researchers have found that during game playing, learners were more active and engaged in learning [1, 2], possessed positive attitude toward learning, and displayed better learning performance [3]. It is found that game can be designed to supplement traditional classroom education through satisfying learners' varied preferences and providing opportunities for learners to think and learn in innovative ways and yet at the same time enhancing learners' performance.

According to Alessi and Trollip [3], the feature of drill game is providing useful learning information for repeated practices rather than oral guidance to enable fluency. The practice itself is very important, and as Alessi and Trollip [3] pointed out, "most educational games at elementary level are in fact drills in game clothing." Content knowledge and procedural skills can be learnt through reiteration with support of instructional strategies and principles designed in games. In this study, we have designed and developed a web-based drill game, which aims at facilitating students' learning through repeated playing experience online. Although several studies were conducted to investigate the effectiveness of drill game on learning mathematics [4], limited research

investigated the effectiveness of and mental aspects toward a web-based drill game on learning resources classification. Therefore the objectives of this study were to:

1. Design and develop a web-based drill game, "Happy Black-faced Spoonbill", for elementary-level students in a cram school to play and record the content of interviews.
2. Use content analysis to investigate each aspect of motivation, attention, perceived ease of use, and perceived usefulness toward the web-based drill game owned by students from the interview data.

Methodology

1. Participants

A total of 12 students consisted of 5 female students and 7 male students of 4th grade to 6th grade volunteered to participate in this study. These students came from a cram school in Taoyuan County in Taiwan. All of these students attended the cram school for additional instruction in English, Chinese, and mathematics.

2. Game Introduction and Design Mechanics

2.1 Game introduction

The web-based drill game, "Happy Black-faced Spoonbill" was designed and developed by NTUST MEG Mini Educational Game Group in 2011 for elementary school students. The web-based drill game in this study was designed to be completed within three minutes for a single drill session, where players can choose to repeat the game for several times. Before each player starts to play, they are free to choose whether they want to view or skip the cover story on the main menu, which will take them one minute to complete. The game consists of the following features. First, learning goals are addressed in a specific way that learners know what should be learnt. In the current study, the game contains both content knowledge of resources classification and the features of drill-based learning, which is about repeated practices to maintain learnt content knowledge. Learning goal of the game is that players will be able to learn content knowledge of classifying resources based upon different classifying features, for instance, most medal objects can transmit heat, reflect light in a certain degree, and so on. Besides, the mission of this game expected learners to classify at least three resources for each of six recycle bins (medal, wooden, paper, plastic, glass, and poisonous bins) correctly. The cover story motivates learners to play within a context where Black-faced Spoonbill lives and to participate in tasks described in the mission. The role set as a curious elementary-level boy who attends to the Double Tenth Day to celebrate with friends and in some reasons becomes a Black-faced Spoonbill to help save the environment.

To connect the game goal/mission and learning goal, the player in the game has to search three resources to complete the game missions. The game interface was designed to be simple and intuitive for players to navigate without instructions and technical help. When students login the game, they can see the cover story, rules and mission, main screen for playing, and the ending story, in order. Players are only given ten health points and 180 seconds to complete the mission. When players are in final countdown, the speed of music will be faster until the time runs out. If the time or health points run out, the game is over. On the main screen for playing, players use the mouse to control the bird (cursor) to move around and clip, drag, and classify the scattered resources to the corresponding recycle bin.

The points are shown under each recycle bin so that players can evaluate how well or how poor they are doing at ease. The feedback is prompted at the bottom right corner of the screen with a Black-faced spoonbill's mad face each time when the player classifies resource wrong to a recycle bin. Also, if players classify resources wrong continuously, the health points will decrease to zero. Besides, players are given a badge on the upper right side of the screen every time when they collect more than three objects of garbage for each classification or recycle bin (e.g. medal) as reward mechanics. When the game is over, the score statistics will give performance of an entire play of the player.
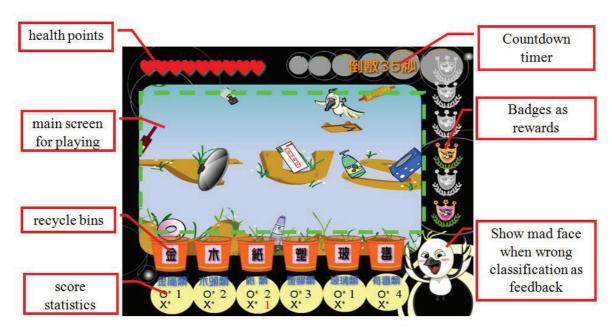
Figure 1. The interface of "Happy Black-faced Spoonbill"

2.2 Design Mechanics

The domain knowledge of the game was fall into environmental sustainability, which encapsulates content knowledge about resources classification and conceptual knowledge of the environmental protection related to environmental sustainability issues. 3R, reuse, recycle, and reduce of used materials has been called on as major policies for environmental sustainability [5]. In addition, knowing how to classify resources (garbage and rubbishes) was deemed as the first step for 3R and for reducing the extremely huge cost managed by public sectors. Moreover, providing a vivid environment for young players to engage and notice the importance of protecting our environment was another focus of this game. Following, game factors will be discussed.

In the web-based drill game, graphic representation was used primarily to mimic authentic objects and living environment to arouse students' attention and concern for environmental issues. Using the mouse was designed as the only method for bird's moving and for selecting objects (resources) in this game because it's easy for novice users and nonreaders or non-typists [5]. In addition, the funny storyline was set up with fantasy atmosphere to further stimulate students to envision themselves in a situation of a black-faced spoonbill that faced an environment with varied kinds of garbage and resources around and to engage in the game task. Mainly, the avatar in the game was a bird, which provides an imaginary experience for players to feel fun. The design of the task was set as intermediate level of difficulty following an expert's suggestion so that students can involve in beneficial challenge and obtain content knowledge of resources classification.

Another factor, discovery, was also designed for players to move around with their cursor on the screen, which encourages them to discover new scene and resources within the main screen.

3. Procedure and Data analysis

At the beginning of the study, participants had received an informal instruction individually for less than 5 minutes about basic features of different kinds of resources, such as medal, wood, paper, plastic, glass, and poison, so that their prior knowledge about resources classification could be controlled as comparably similar to each other. Basic features such as glass as fragile, medal as malleable, and so on were introduced. Then, the students were invited to play the game individually. Following the first trial of the game was an interview conducted to probe players' feedback and understanding toward the game. The reason that interview was adopted in this study was because participants are not able to recognize the 'right' classification and the survey results can not reflect their true behavior, cognitive process, and error patterns [5].

Interview questions were designed to probe different aspects of motivation and attention. For motivation, major questions prompted, 1) Do you like this game and why? 2) Which part of this game you think is interesting and why? 3) Through this game, would you like to learn resources classification better? For attention, major questions included, 1) Were you diffused or concentrated while playing the game and why? 2) What was the most appealing part of the game to you and why? 3) Did you notice the cover story/main playing screen/score statistics and why?

Then each student was asked whether they want to play again the game. The treatment stopped whenever they required quitting the game. Following the game was a second interview session conducted to probe the players' perceived ease of use and usefulness toward the game. Major questions for perceived ease of use and perceived usefulness were, 1) Do you think this game was easy or hard to handle with and why? 2) Do you think this game was helpful in learning resources classification and why? The interview sessions lasted within 30 minutes.

Content analysis was utilized to analyze students' responses to the interview questions. After reading every single response from the 12 participating students and organizing the responses into systemic categories, two coders (researchers) coded each response to each question accordingly. The coders read all of the responses first, coded important keywords until categories emerged from similar codes, and discussed and reached consensus in categories and criteria. Their inter-coder agreements for these analyses were assessed and reported as greater than 0.80. In addition, the two researchers discussed the discrepancies and achieved the final level of agreement.

Results and Discussion

All participants were free to decide how many times to play the game during fifteen minutes so that students had enough time to explore on the game. Students' responses to the interview questions after they finished the game were categorized and summarized in Table 1 to Table 4 based upon main four perspectives, students' motivation, attention, perceived ease of use and perceived usefulness toward the game, consecutively. All numbers in four tables were only represented as the frequency and percentage of agreement to the corresponding question/dimension. For instance, if one boy agrees that he was alert by the main screen, then his response will be counted as one. Besides, The mark of * in Table 2 and Table 3 indicates each sub-category underneath the main category

consists of one question. That is, it consisted of 3 different questions for the main category, *Intensiveness* in Table 2, while there were 2 questions for the main category, *Clear and Understandable* in Table 3.

1. Motivation

The study categorized four main aspects of motivation toward the game, such as fun, fantasy, challenge, and learning based on interview data as well as literature review [3]. As students were asked to describe the reasons why they wanted to replay the game, it is found that all students experienced fun in the web-based drill game, except for one girl as shown in Table 1. For example, student #s04 mentioned, *"The game is fun. I like the game because it's more interesting during class."* Besides, student #s05 described, *"I think the cover story is fun because it can make the whole class laugh"* Also, student #s07 indicated, *"The cover story teaches me about garbage classification and makes me feel the game following (the story) will be fun and hilarious."* The game offers interesting and novel contexts that stimulate students' motivation to explore unknown environment. Players with fun experience may be more immersed in the learning environment provided by the game. The characteristic of fun proved to be major motivation for students to play and learn.

In this study, all the students played the game at least twice and were motivated to take up challenge. 67 percent of students mentioned that they wanted to play again because they were not satisfied with their performance in the previous trial. For example, student #s09 indicated, *"Since I didn't figure out how to play it well, I did not play it well at the first time. But I really desire to try again once I have the previous experience."* Also, student #s06 pointed out, *"I want to try again, because I want to break the record!"* It is worth of notice that comparably more boys than girls mentioned challenge as a main factor, which motivated them to play the game. During the first trial of the game playing, students may have some unclear concepts in resources classification. However, students may benefit from the following trials to notice and correct their mistakes. The triggered element of the game, challenge, can also be found in students' intention to compete against oneself. For instance, both student #s08 and student #s12 mentioned, *"I want to try again to see if I can make great progress next time."*

58 percent of students described their game playing experience as a novel one which is different from the real world. For example, students mentioned that the feeling of fantasy from the cover story and role-playing experience aroused their interest in playing the game. Student #s08 pointed out, *"It is incredible that a bird can pick up the trash!"* In addition, Student #s09 mentioned, *"I think it is a lot of fun when I saw the bird in the cover story. I wonder what I am going to play later on."*

The experience of learning was shown to be another dimension of motivation while playing the game. Students did enjoy playing the game and learning when they sense their progression. As show in Table 1, all students mentioned that they were motivated to learn better on resources classification after playing this game. However, the experience of confronting ill-equipped problems will decrease students' motivation. Student #s01 pointed out, *"I do not have confidence in operating that (mouse) better because that (mouse) is hard to control for me."* Student #s05 also mentioned, *"I think this game is alright but the mouse is hard to control."*

Table 1. Frequency and percentage of the motivation toward the game

	Fun	Challenge	Fantasy	Learning
Girls	4 (80%)	2 (40%)	3 (60%)	5 (100%)
Boys	7 (100%)	6 (86%)	4 (57%)	7 (100%)
total	11 (92%)	8 (67%)	7 (58%)	12 (100%)

Note: n=12 (Girls: 5; Boys: 7)

2. Attention

To investigate players' attention toward the web-based drill game, the interview data were closely examined and compared with findings in the literature [6] and finally coded into three dimensions, which are, 1) distribution (diffused versus concentrated); 2) selectivity (the "what" of attention); 3) intensiveness (alert versus inattentive). As shown in Table 2, there was only one female reported that she was in a medium level of concentration, while most of other children reported that they were concentrated during the play. Among them, one girl #s02 and one boy #s07 mentioned that they were concentrated because the game was fun. Besides, one girl #s04 and two boys, #s09 and #s11, were concentrated because of focusing on classification itself. For instance, student #s04 said, *"I was concentrated since I would like to classify more and reduce the frequencies of my classifying wrong."* Also, student #s09 indicated, *"I was not diffused because this is a classification game and I need to focus on the classification."* Student #s012 revealed, "The reason I was concentrated was because of the homework I have not yet finished."

As for the "what" of attention students had, there were 42 percent of students mentioned that the main screen was appealing to them while there were also 42 percent of children said that it was the classification and statistics areas attracted their attention. For example, student #s02 indicated that the game provided a sense of adventure especially when the bird was flying. A male student even asked, *"It was most appealing to me why the bird can catch the garbage."* The same importantly, students who mentioned that the classification and statistics areas attracted them were those who care about goal and performance achievement. For instance, student #s11 said, *"The most appealing thing to me was that if I can get the score I will be happy."* Even though the number of mentioning the cover story as their selectivity was comparably low, 20 percent of girls and 14 percent of boys still mentioned that the cover story was fun, interesting, and creative. A possible reason that most students did not select the story as their major choice for attention could be their disfavor of birds' droppings in the cover story. As for gender difference, it was found that comparably more male students were appealed to the classification and statistics areas. The findings of intensiveness were parallel to the selectivity of attention as mentioned above. All students were alert by the main screen area and 92 percent of students were alert by the classification and statistics area.

Table 2. Frequency and percentage of attention toward the game

	Distribution	Selectivity			Intensiveness		
	Concentrated	Story	Main screen	Statistics	Story[*]	Main screen[*]	Statistics[*]
Girls	4 (80%)	1 (20%)	3 (60%)	1 (20%)	4 (80%)	5 (100%)	4 (80%)
Boys	7 (100%)	1 (14%)	2 (29%)	4 (57%)	5 (71%)	7 (100%)	7 (100%)
Total	11 (92%)	2 (17%)	5 (42%)	5 (42%)	9 (75%)	12 (100%)	11 (92%)

Note: n=12 (Girls: 5; Boys: 7), [*] indicates each sub-category consists of a question.

3. Perceived Ease of Use and Perceived Usefulness toward the game

3.1 perceived ease of use

To evaluate students' perceived ease of use toward the game, the interview data were finally coded to three dimensions: easy to handle, intuitive design, and clear and understandable. As shown in Table 3, it was found that 58 percent of students expressed that the game was uneasy to handle with. Especially, student #s09 mentioned, "when I

was moving the mouse, sometimes the cursor on the screen will leap out if my movement was too big." Only 42 percent of students thought that the game was easy to handle with. For instance, a male student #s08 said, "it's easy to operate and there is no reason…there is no problem for me to control the bird using the mouse."Girl #s02 said, "It's easy since I played it for three times and I get used to it, so there is no problem for me." It seems to be a problem that students encountered obstacles in controlling the mouse. Especially, a boy #s06 said, "Actually I understand how to handle (it) but the mouse is too big for me…it will fall down if I didn't control it well."

As for the intuitive design of the game, 67 percent of students agreed that the game design was intuitive. For example, male student #s12 indicated, "Because the beak clipart looks just like the tool for holding the resources." In addition, all students expressed that the rules and score statistic areas were clear and understandable. Boy #s12 said, "It's easy for me to understand because there are numbers shown over there and it's clear." When asked about level of difficulty of the game, 17 percent of students said it was very easy, 67 percent of students said easy, and 17 percent of students said the difficulty is moderate.

Table 3. Frequency and percentage of perceived ease of use toward the game

	Easy to handle	Intuitive design	Clear & understandable	
	Easy	Agree	Rules & missions[*]	Statistic[*]
Girls	1 (20%)	3 (60%)	5 (100%)	5 (100%)
Boys	4 (57%)	5 (71%)	7 (100%)	7 (100%)
Total	5 (42%)	8 (67%)	12 (100%)	12 (100%)

Note: n=12 (Girls: 5; Boys: 7), [*] indicates each sub-category consists of a question.

3.2 Perceived usefulness

To evaluate students' perceived usefulness toward the game, the interview data were coded into three dimensions. As shown in Table 4, three dimensions mentioned above are: performance improvement, knowledge acquisition, and comparison of learning effect. First of all, all students reported that the web-based drill game would improve their learning performance. For example, student #s04 mentioned, *"The game will help me learn. Once something I did wrong the first time, I understood that it was not belonged to the category that I thought previously. Therefore, I would try to think whether it belongs to another category and try it again to see if I classify it right this time."*

As for knowledge-acquisition, which can be referred to knowledge learnt and acquired from game playing experience, all students except for one girl mentioned that they understood the principles of classification more clearly and gained some new concepts of classification. For example, student #s06 mentioned, *"The game helps me understand what kind of resources would be harmful to the earth…for example, battery within the poisonous category."*

Finally, as we asked students to further compare the effectiveness between their previous learning experiences of resources classification with the experience of the current game, 33 percent of students mentioned that they experienced equally effective, and 58 percent of students regarded the game as more effective. Student #s12 mentioned, *"When comparing with my previous learning experience, this game was more effective. Because the game contains more resources and it seems to have more classifications, I think it's even harder and that's why it is more effective."* Also, student #s04 pointed out, *"Compared to in-class learning, this game was more effective because the textbook*

consists of more text than pictures usually. So I did not want to read. Therefore, I thought this game to be more fun and I will be more likely to learn through it."

Table 4. Frequency and percentage of perceived usefulness toward the game

	Performance improvement	Knowledge acquisition	Comparatively more effective
Girls	5 (100%)	4 (80%)	4 (80%)
Boys	7 (100%)	7 (100%)	3 (43%)
total	12 (100%)	11 (92%)	7 (58%)

Note: n=12 (Girls: 5; Boys: 7)

Conclusion

This paper was intended to examine the learning effectiveness of the web-based drill game through query students' motivation, attention, perceived ease of use, and perceived usefulness. From the interview data, we found that the web-based drill game could be useful in helping learners to acquire and practice the targeted content knowledge. Firstly, players with fun experience may be more immersed in the learning environment provided by the game. Also, the fantasy context provided by the game was found to be significantly attractive to students to learn content knowledge. As for players' attention toward the game, most children reported that they were concentrated during the play. The game therefore seemed to be able to catch players' attention. About the selectivity of attention, 42 percent of students said it is the main screen for playing, while there were also 42 percent of students mentioned that the scores statistic area was most appealing to them. It was also found that the classification and statistics areas attracted comparably more boys than girls. As a result, providing fun, points, and rewards thus seemed to be important and attractive in game design for obtaining learners' attention and targeted learning outcomes. Last but not least, the game with ease of use and usefulness features could facilitate students to improve their learning performance, increase knowledge acquisition, and experience more effective learning. The limitation of this exploratory study is the sample size and the restriction of the data to one cram school only, which limits the generalization of the results. However, the design of the web-based drill game in this study was a prototype useful for future modification.

Acknowledgments

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