Hirashima,T. et al. (Eds.) (2010). Workshop Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

Applying a Three-Dimensional Computer Game to Facilitate Learners' Using a Compass to Solve Orientation Problems: A Case Study

Chung-Yuan HSU[a], **Huei-Tse HOU**[b]
[a]*Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taiwan*
[b]*Graduate Institute of Engineering, National Taiwan University of Science and Technology, Taiwan*
jackohio@gmail.com
hthou@mail.ntust.edu.tw

Abstract: Recently, limited research examines how 3D game-based context influence students' acquisition of both cognitive and procedural knowledge, such as using a compass to solve orientation problems. The purpose of this study was to explore the implementation of a computer game for learning how to use compass. A three- dimensional (3D) computer game named *Treasure Hunting* was developed by the researchers. A male and female volunteer of grade 3 and 4 were recruited to take the treatment. The results of the post test and the retention test showed that the students in a 3D game-based environment were able to acquire the compass-using skills. The results also provided some practical suggestions to science educators or instructional designers interested in implementing game-based learning as an alternative way to enhance students' conceptual understanding.
Keywords: Game-based learning, science education, virtual reality, game.

Introduction

Instructional problems of a superficial understanding still prevail in current education. Educational researchers recognize that students can get superior test scores but possess shallow and isolated understanding of the targeted knowledge. Take science education for example, Tsai (1998) pointed out that students were inclined to use rote memorization to acquire scientific knowledge, which later hindered the usage or application of the knowledge in an appropriate context. To remedy the shadow learning problem and enhance learning performance, many educators seek solutions from technology, particularly digital game-based learning (GBL) (Annetta, Minogue, Holmes, & Cheng, 2009; Tuzun, Yilmaz-Soylu, Karakus, Inal, & Kizilkaya, 2009).

The three-dimensional (3D) virtual environment in games, according to Wann and Mon-Williams (1996), "provide the user with access to information that would not otherwise be available at that place or time, capitalizes upon natural aspects of human perception by extending visual information in three spatial dimensions" (p. 833). Findings from Tuzun et al.'s study (2009) on implementing a computer game for learning geography indicated that 3D environment together with GBL could not only promote students' learning outcomes but also enhance their engagement in the learning activity. Although several studies were conducted to investigate the influences of integrating 3D environment and GBL on cognitive learning, such as geographical information (Tuzun et al., 2009) and genetics (Annetta et al., 2009), limited research examined how 3D game-based context influence students' acquisition of both cognitive and procedural knowledge, such as using a compass to solve orientation problems. Therefore, the aim of the present study was to investigate whether the 3D game-based environment could be employed to facilitate students' learning a compass. A 3D computer game named *Treasure Hunting* was developed by the researchers and it includes inquiry tasks, challenges and time limitation. Two students were recruited to play the game, take the post test and retention test in this case study. Discussions and suggestions about game design were also proposed.

Methodology

Participants

A male student of 3rd grade and a female student of 4th grade volunteered to participate in this study. They had not received any formal instruction about using a compass and had no prior knowledge about using a compass.

Procedure

The students were first informed the aim of the study and then took the treatment individually. Each participant's playing process together with audio were recorded by screen capture software for later analysis. The treatment stopped whenever they successfully achieved the goal in the game. Following the game was an interview conducted to probe the players' understanding as well as their feedback about the game. Questions prompted included, 1) what is the purpose of using a compass? 2) How do you guide a person to use it? 3) How did you feel while playing the game? 4) How did you react when attacked by the enemy? 5) Did the attack by the enemy or eating food influence your searching diamonds, and How? After three weeks, each student was interviewed again to examine how much the targeted knowledge he or she retained.

Instrument

The researchers developed a game named, *Treasure Hunting*, by using an authoring tool *Virtools Dev 3*. To connect the game goal and educational goal, the player in the game had to search three diamonds in order to complete the inquiry-based missions. Since these diamonds were located in a vast virtual environment, searching all the diamond within limited time required the players to utilize the orientation bases (to gain information about the directions of diamonds) as well as a compass. To provide an exciting and emotionally

Countdown
Display the time remained.

3D Environment
Includes continent, forest, enemy, and statues.

Avatar
Players can use the keyboard to search the diamonds in the game environment

Figure 1. The interface of *Treasure Hunting* game

Compass
Allows players to determine the direction of the target destination.

Orientation Base
Offers the directions of diamonds.

Energy Bar
Displays the avatar's energy status.

appealing experience, challenges such as enemy attacks and time limitation were imposed on the players. The participants had 10 minutes to complete the task and the time was displayed through a countdown shown on the top-left area of the screen, as illustrated in Figure 1. An enemy would appear and attempt to kick the player whenever the first diamond was found. When under attack, the avatar's moving speed would decline and the energy bar on the right part of the screen would become empty. The player had no way to avoid the attack unless the avatar ate sufficient food to speed up the movement so as to run away from the attack. During the playing process, each student's behaviors would be saved into a log file for further analysis.

Results and Discussion

Both participants took three times to win the game. In their last trials, Andy spent nine minutes 25 seconds and Betty spent about seven minutes to complete the task. The users' behavioral logs that recorded frequency for five main behaviors in each trial were shown on Table 1. As shown, both players employed the orientation bases and set the compass more than three times in their successful trials. This may indicated that they did rely on using the compass to find the diamonds, rather than searching by lucks. Although Betty used the compass more than three times in her first trial, most usages were wrongly operated according to the analysis of the video record.

Analysis of video clips and users' behavioral logs could explain the causes to failure in their first two trials. Andy tended not to utilize orientation bases (to gain information about the directions of diamonds) and the compass in his first trial. He tried to find diamonds by lucks instead, which was displayed as low frequency in the behaviors of setting compass and using orientation bases in Table 1. In the second trial, his strategy to deal with the enemy' attack was running away, which certainly drove him away from the path to get the diamond. Regarding Betty, the unfamiliar usage with the compass hindered her achieving the task in the first two trials. For instance, she either forgot to turn the compass housing to align with the directional arrow or inaccurately aligned the compass needle with the orientation on the compass housing. However, in the second trial she seemed to realize that eating more food would speed up the character's movement, which allowed avoiding the enemy's attack. With experiences from the first two trials, both players became more acquainted with the usage of the compass and could complete the task in the third trial. This implied that the 3D game-based learning environment provided an context for the players not only to construct their understanding to compass usage but also to gain practical experiences in using a compass.

Table 1. Frequency table of playing behaviors

	Set compass	Orientation bases used	Food	Attacked	Diamond found
1st (Andy)	2	1	6	6	1
2nd (Andy)	2	4	5	1	2
3rd (Andy)	4	5	7	5	3
1st (Betty)	6	3	6	7	2
2nd (Betty)	5	4	9	3	2
3rd (Betty)	5	3	8	3	3

After completing the game, an interview was conducted to investigate their experiences in playing the game and to probe their understanding about using a compass. Both participants expressed that they had anxious feeling while walking a long way without finding the diamond. They doubted that they might use the compass in a wrong way. For

example, Andy said that, "Where is the diamond? I have been walking a long way but still cannot find it". Similarly, Betty impatiently murmured to give up playing since she could not see the diamond and suspected that she might misuse the compass. This finding indicated that the 3D game-based learning context was able to offer learning experiences as richly situated and immersive as the real-life context provided, which helped learners to reflect their learning process/strategies, and construct solid and deeper understanding.

When asked the feeling about being attacked, Betty indicated that the enemy's attack was frustrated and made her move slowly by taking out all the energy. Andy expressed that, "It was exciting to be chased by the enemy and I had to eat food [to increase the moving speed] so as to prevent the attack." This implied that the challenge component of game design might promote the players' emotional involvement and decrease a sense of boredom. To investigate the participants' understanding about using a compass after the treatment, a post-test and retention test were conducted through two interviewing questions including 'what is the purpose of using a compass?', and 'how do you guide a person to use it?' Both participants could explicitly describe the aim as well as demonstrate the process of using a compass while asked to do so. As Andy described, "the purpose [of using a compass] was to help one head to the right direction". "The compass can tell me right direction", said by Betty. The retention test took place after three weeks. Both students seemed to have difficulty explaining the usage of a compass without seeing a compass. But, when displaying a compass they could demonstrate the way to use a compass accurately and fluently. This implied that the 3D game-based learning environment could facilitate the students' acquisition of compass-using skills in a certain degree.

Discussion and conclusion

The purpose of this case study was to explore whether the 3D game-based environment could be employed to help students learn how to use a compass. The findings showed that the 3D game-based context is an ideal and situated environment for students to acquire and practice the targeted skills. This is in agreement with Annetta et al.'s (2009) study claiming that:

> The practice of learning a video game is an enculturation practice that involves not only learning the mechanics of game play, but learning how to negotiate the context of play, the terms and practices of a game's players, and the design choices of its developers (p. 79).

In addition, during the game-playing process the students encountered the same difficulties as those that might occur in a real-life learning environment, such as feeling astray, failing to remember how to use compass, and feeling frustrated during the long searching process. The difference is that all the difficulties they dealt with took place in a virtual environment that prevents them from generating a sense of embarrassment by making mistakes in front of many students. Further, failure is free and students can take time to remediate it, which makes education more efficient (Baek & Parker, 2009).

One suggestion about game design was proposed in the present study. The researchers found that an instructional video clip was offered to guide compass usage in the beginning of the game. But, both players tended not to browse it or browsed it incompletely, especially in the first trial. Even though the researchers tried to keep the clip concise and short, the players could not wait to play the game immediately. Thus, it is suggested that game designers can embed essential instruction into the initial level of the game to make sure that the users become acquainted with the rules before playing the game. In addition, it is also suggested that future studies can examine whether the players can transfer what they learn in the game context to a real-life context by asking them to use a real compass to find an objects. Further,

in the field of science education, many studies have been conducted to investigate how students' self-efficacy (Schmidt & Ford, 2003) or epistemological beliefs (Tsai, 1998, 1999) influence their knowledge construction. It is an interesting topic for future researchers to investigate how 3D computer games can influence the learning of students with either low self-efficacy or naïve epistemological beliefs.

The ultimate goal of game-based learning is to encourage players to think and explore during game-playing process and then reaches conceptual changes after playing. This is a formidable challenge since the participants, especially during the first time playing, tended to employ a trial-and-error strategy to achieve the task. Thus, maintaining appropriate level of challenge may inform the players the fact that their way 'do not work' and take the approach that the designer would like to transmit instead. In addition to level of difficulty, the game design should pay more attention to incorporate components that may create conceptual conflict and promote cognitive accommodation.

References

[1] Annetta, L., Minogue, J., Holmes, S., & Cheng, M. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers & Education, 53*(1), 74-85.

[2] Baek, Y. & Parker, J. R. (2009). A Simulation Primer. In D. Gibson & Y. Baek (Eds.), *Digital simulations for improving education: Learning through artificial teaching environments* (pp. 1-24). Hershey, PA: Information Science Reference.

[3] Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

[4] Tsai, C.-C. (1998). An analysis of scientific epistemological beliefs and learning orientations of Taiwanese eighth graders. *Science Education, 82*(4), 473-489.

[5] Tuzun, H., Yilmaz-Soylu, M., Karakus, T., Inal, Y., & Kizilkaya, G. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education, 52*(1), 68-77.

[6] Wann, J., & Mon-Williams, M. (1996). What does virtual reality NEED?: human factors issues in the design of three-dimensional computer environments. *International Journal of Human-Computer Studies, 44*(6), 829-847.

[7] Tsai, C.-C. (1999). The progression toward constructivist epistemological views of science: a case study of the STS instruction of Taiwanese high school female students. *International Journal of Science Education, 21*(11), 1201-1222.

[8] Schmidt, A., & Ford, J. (2003). Learning within a learner control training environment: The interactive effects of goal orientation and metacognitive instruction on learning outcomes. *Personnel Psychology, 56*(2), 405-429.