SATOYAMA: Time-limited Decision Game for Students to Learn Hundreds Years Forestry Management

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Abstract: Global environmental problems continue to worsen. In this situation, it is important to understand and experience changes in the natural environment in realistic ways. However, it was difficult to experience these changes in real time because they happen over large time scales. To overcome this problem, the authors developed a game-like learning tool that enables players to learn about vegetation succession. This game is Windows-based and enables players to simulate the conservation of SATOYAMA, rural natural areas. The player selects the actions within a designated time and the vegetation succession of the SATOYAMA changes according to that action. At the end of this game, the score is based on the SATOYAMA conserved by the player. Thirty-seven students participated in this experiment whose result suggested that this game would enable children to develop an interest in vegetation succession and motivate them to learn about it.

1 INTRODUCTION

In recent years, the environmental problem has been worsening globally. In this situation, it is important to understand and experience changes in the natural environment in a realistic way. However, one of the difficulties in this endeavor is the fact that theoretical learning about the subject (as taught by teachers and textbooks) does not provide a real experience of the actual world. As a result, rural natural areas known as SATOYAMA are gaining attention as places where one can acquire practical knowledge of the environmental problem. The key concepts in understanding SATOYAMA involve complex mechanisms that are concerned with the actual situation of vegetation succession. However, practical knowledge of these concepts cannot be had simply by reading textbooks or watching films. Moreover, since real vegetation succession happens over large time scales such as tens or hundreds of years, it cannot be completely experienced in SATOYAMA-based fieldwork. For that reason, it is difficult to understand vegetation succession in a realistic way. To overcome these problems, it is necessary to develop game-like learning tools that enable students to learn about vegetation succession without being limited by the large time scale involved in it. There have been many studies related to using games for learning (Facer, et al., 2004, Squire and Klopfer, 2007). These earlier studies have revealed that the simulation provided by games can help students gain the ability to understand the microscopic and macroscopic worlds. However, ours is the only pedagogical initiative that focuses on learning about environmental problems through vegetation succession in SATOYAMA.

The authors have developed "Human SUGOROKU" that has the conservation of SATOYAMA as an exercise for learners to work with a familiar environmental problem. In this game,

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the change of the dominance of the indicator plant, due to the environmental disturbance factor (felling, landslide, precipitation and so on), is expressed in the SUGOROKU format. In addition, we have conducted advanced research on a learning material that visualizes vegetation succession of the SATOYAMA using animation (Deguchi, et al., 2010, Deguchi, et al., 2012). As a result, it was found that the game enhances the will to learn, deepens the understanding of complex vegetation succession, improves the ability to solve problems in matters related to vegetation succession, and so on (Adachi, et al., 2013, Nakayama, et al., 2014, Yoshida, et al., 2015). However, the scene in which the game was set was restricted to a particular area. In this game, large-scaled ultrasonic sensors were used and learners worked on the squares arranged in the virtual world disguised as indicator plants; but this merely realized restricted immersion. Therefore, the following four observations were made:

- Competitive relationship between plants and environmental disturbance factors in various areas could not be expressed.
- The propagation of this game was difficult because of large scale devices used in it and its lack of portability.
- Restricted embodiment could not provide the learners with the experience of complete immersion in the virtual world.
- The contents of the game could not be adapted to the intelligence of the learners.

Therefore, in order to deepen understanding and improve the problem-solving abilities of the learners in the area of vegetation succession, the authors decided upon the following objectives for the current study:

- Developing a wide range of contents including main vegetation succession in each area of Japan.
- Making a portable game by using mobile devices.
- Making the contents of the game adaptable to the intelligence of learners.

As the first step in this endeavor, this paper presents the details of the current implementation of the game and the experiments conducted with it.

2 IMPLEMENTATION OF THE CURRENT GAME

2.1 Purpose of the Game

We name the game introduced in this paper, SATOYAMA Management Game. SATOYAMA is the nature of human beings. The SATOYAMA Management Game can simulate the management of the environment for the players. Events to be managed include the following:

- Afforestation
- Deforestation
- Pesticide Application
- Removing Deer

The player chooses either one or none of the above-mentioned actions within a fixed time. The SATOYAMA`s vegetation changes according to the selected behavior. Players manage the SATOYAMA starting from the ideal environment through 20 turns each. Then, at the end of the game, the final state of the SATOYAMA compared to the ideal state is the score by doing so, the players can experience the

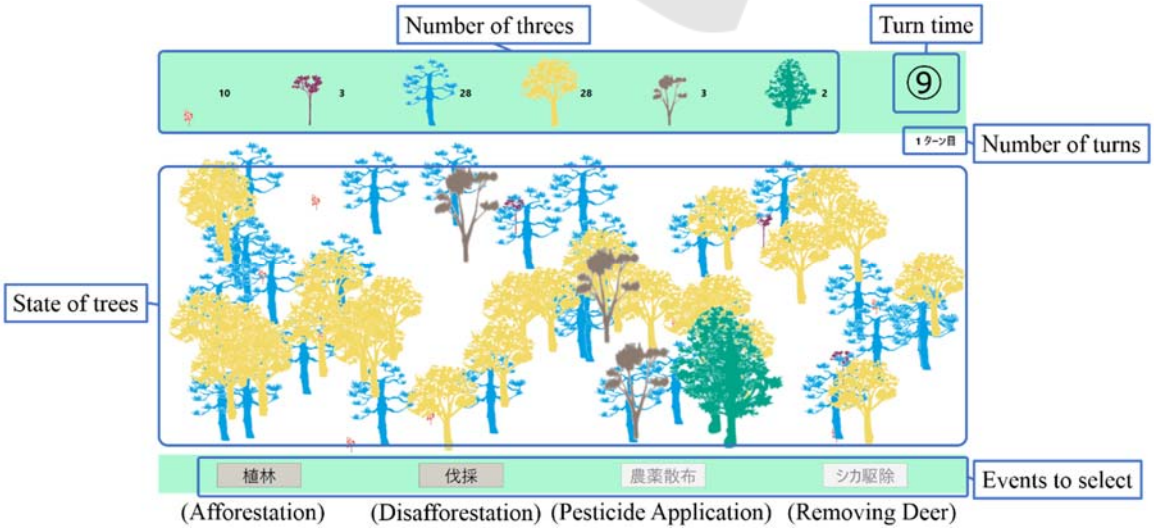

Figure 1: Game screen.

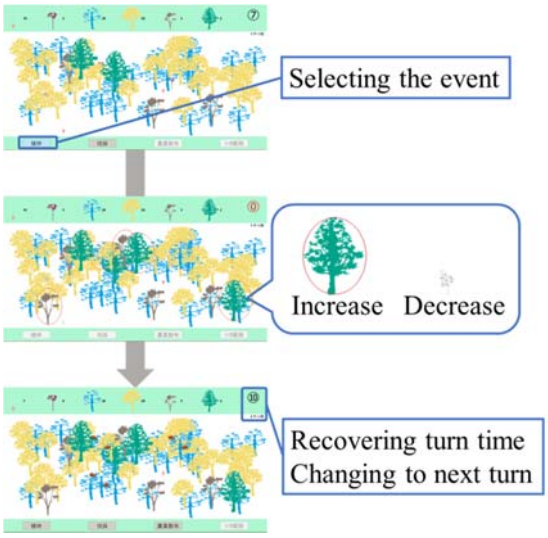

Figure 2: Game flow.

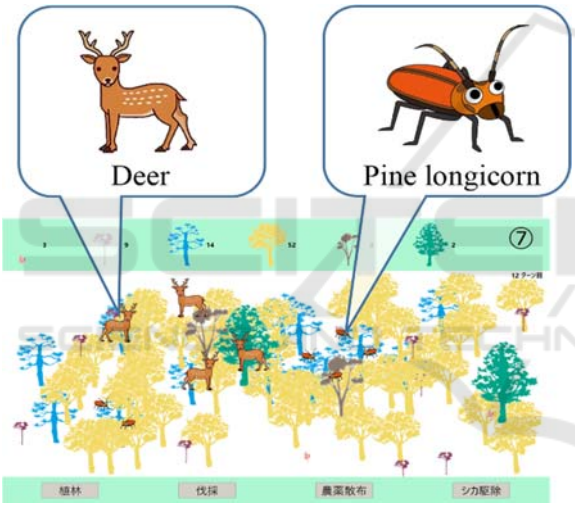

Figure 3: The appearance of pine longicorn and deer.

vegetation succession in a realistic way.

The following six kinds of plants grow in the SATOYAMA Management Game:

- Small plants: *Rubus microphyllus* *Mallotus japonicas*
- Medium sized plants: *Pinus densiflora*, *Quercus serrata*
- Tall plants: *Ilex pedunclosa*, *Castanopsis* spp.

These plants have different growth rates and sizes. *R. microphyllus* and M. japonicas are rapidly growing small plants, *P densiflora*, and *Q. serrata* grow at moderate rates, *I. pedunclosa* and *Castanopsis* spp. are tall and slow growing plants.

Moreover, there is competition between plants. This occurs when two or more plants grow in the same place. For example, if a tall plant and a small plant grow in the same densely forested area, the tall plant gets the sunlight it needs to grow but the small plant does not. Therefore, the number of small plants will decrease. In the SATOYAMA Management game, the beginning starts in an ideal environment. The ideal environment is one in which many medium sized plants grow. An ideal SATOYAMA is shown in Figure 1. If the players do not manage the SATOYAMA, the competition between the plants will result in the vegetation consisting only of tall plants. To prevent this, the player can choose between "Afforestation" and "Deforestation." Figure 2 shows the changes in vegetation caused by the player selecting one of these events. However, when planting trees or causing deforestation, deer and pine longicorn appear. Figure 3 shows the appearance of pine longicorn and deer. To remove these, the two actions of "Pesticide Application" and "Removing Deer" can be used.

Players can visually understand the state of vegetation succession through the SATOYAMA Management Game. Therefore, students playing games can easily understand the mutual action that occurs between plants, the effect of different events on the SATOYAMA, and the management of the SATOYAMA. The vegetation succession is represented by the relative relationship of each plant.

2.2 Configuration of the System

The system consists of a screen, a short focus projector, a personal computer (PC), and a mouse. When the player uses the mouse and selects an event on the screen, a corresponding change occurs in the SATOYAMA. These operations and controls were implemented using a C# program that we developed using Visual Studio 2013. With this program, it is possible to increase or decrease the numbers of each plant arbitrarily.

Table 1 shows the relationship between each event and the increase and decrease of the number of plants. SATOYAMA starting from the ideal state changes every time. If the player selects "Afforestation," medium sized plants will increase.

Selecting "Deforestation" reduces the number of tall plants. When the number of P. densiflora reaches six or more, the pine longicorn appears. When the number of R. microphyllus reaches three or more, deer appear. Their appearance is not random. The influence on the vegetation by the two organisms depends on the characteristics of the plants. Pine longicorn appears in P. densiflora, so P. densiflora is markedly reduced. On the other hand, the small plants increase owing to the competition between the

Table 1: The relationship between each event and the change in the number of plants.

Events \ Plants	*R. microphyllus*	*M. japonicus*	*P. densiflora*	*Q. serrata*	*I. pedunclosa*	*Castanopsis* spp.
Afforestation			Increase	Increase		
Deforestation	Increase	Increase	Increase	Increase	Decrease	Decrease
Pine longicorn	Increase	Increase	Decrease			
Pesticide Application	Stopping the decrease in plants caused by Pine longicorn					
Deer	Decrease	Decrease	Decrease	Decrease		
Removing Deer	Stopping the decrease in plants caused by Deer					
and grow in every turn. If the total number of or are more than 0, the other plants decrease.						

plants. If “Pesticide Application” is chosen, it can prevent the decrease of P. densiflora. While the deer eats all kinds of plants, it prefers small plants and seedlings. Therefore, when the deer appear, there is a great decrease in the small plants. On the other hand, if the player chooses the option of “Removing Deer,” the number of the small increases more than the other plants. In the meanwhile, the tall plants continue to whether or not events occur. Furthermore, when the tall plants grow, the number of small and medium plants decreases owing to the competition.

3 EXPERIMENT

3.1 Method

Participants: Thirty-eight 6th grade students from elementary schools affiliated to a national university corporation.

Procedures and challenges: A game simulating the management of undeveloped woodlands near populated areas was played thrice by each participant. The game was played by one participant at a time. Each participant was asked to consider a strategy before the commencement of each game. After playing three rounds, the participants were asked to evaluate their gaming experience by rating their response to the two types multiple-choice of statements. The first one listed the following four options: 1) “I enjoyed playing the woodlands management game,” 2) “The game got me engaged in woodlands management,”; 3.) “I was emotionally affected by the score (happy, disappointed etc.),” and 4) “I was happy when I was able to accurately predict changes caused by such actions as tree planting, lumbering, pesticide spraying, and deer culling.”

Figure 4: Environment of the Experiment.

The other type comprised the following two

statements pertaining to the user interface: 1) "Viewing the screen of the woodlands management game made it easy to see the condition of the woodlands," and 2) "The woodland management game was easy to play." The responses to each of the six statements were rated on a 7-point Likert scale that ranged from "Strongly Agree" to "Strongly Disagree."

The survey was conducted from December 19 to 22, 2016. Figure 4 shows the environment of the experiment.

3.2 Result

We sorted the responses into positive (Strongly Agree, Agree, Somewhat Agree), and neutral/negative (Neither Agree nor Disagree, Somewhat Disagree, Disagree, Strongly Disagree). We then analyzed the number of positive and neutral/negative responses by using Fisher's exact test, with a 1 x 2 contingency table.

Table 2 summarizes the questionnaire results. When evaluating the results of user engagement with the woodlands management game experience, positive responses to all four statements outnumbered neutral/negative responses. A significant bias was observed among the number of responses.

We then evaluated results for the woodlands management game interface. Positive responses to both questions again outnumbered neutral/negative responses, and a significant bias was again observed among the numbers of responses.

4 CONCLUSIONS

This paper concerns development and evaluation of a game for managing undeveloped woodlands near populated areas; the game also provides practical training by simulating woodland management experience. Positive responses outnumbered neutral/negative responses for all four items regarding user engagement of the game, and for both the items concerning the user interface. The difference between the numbers of responses was significant.

These results show that the participants played the woodland management game with enthusiasm. The results also show the participants put considerable thought into game strategies pertaining to simulated changes in the woodlands.

Possible additions to the study may be the conducting of a video analysis of the participants playing the game, and qualitatively evaluating the effectiveness of the game as a tool for studying plant succession and learning woodland management support. Other possibilities would be to conduct a comprehensive analysis of data obtained by evaluation tests, and to discuss ways in which the game may be improved.

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REFERENCES

Facer, K., Joiner, R., Stanton, D., Reid, J., Hull, R. & Kirk, D. (2004) 'Savannah: mobile gaming and learning?', *Journal of Computer Assisted Learning*, vol.

Table 2: Subjective assessment of woodlands game experience.

Statements	7	6	5	4	3	2	1
I enjoyed playing the woodlands management game. **	22	15	1	0	0	0	0
The game got me engaged in woodlands management. **	17	15	6	0	0	0	0
I was emotionally affected by score (happy, disappointed etc.) **	16	16	4	2	0	0	0
I was happy when I was able to predict accurately the changes caused by such actions as tree planting, lumbering, pesticide spraying, and deer culling. **	9	22	5	2	0	0	0
Viewing the screen of the woodlands management game made it easy for me to see the condition of the woodlands. **	19	9	8	2	0	0	0
The woodland management game was easy to play. **	22	8	5	3	0	0	0

N = 38, 7: Strongly Agree, 6: Agree, 5: Somewhat Agree, 4: Neither Agree nor Disagree, 3: Somewhat Disagree, 2: Disagree, 1: Strongly Disagree, **; $p < 0.01$

20, no. 6, November, pp. 399-409.

Squire, K. & Klopfer, E. (2007) 'Augmented Reality Simulations on Handheld Computers', *The Journal of the Learning Sciences*, vol. 16, no. 3, April, pp. 371-413.

Deguchi, A., Inagaki, S., Kusunoki, F., Yamaguchi, E., Takeda, Y. & Sugimoto, M. (2010) 'Vegetation Interaction Game: Digital SUGOROKU of Vegetation Succession for Children', In *Proceedings of the 9th International Conference on Entertainment Computing(ICEC2010)*, September, pp. 493-495.

Deguchi, A., Takeda, Y., Kusunoki, F., Tanaka, M., Inagaki, S., Yamaguchi, E. & Sugimoto M. (2012) 'Development and evaluation of a digital environmental learning game for children', In *E-Book Proceedings of the ESERA 2011 Conference: Science learning and Citizenship*, pp. 26-32.

Adachi, T., Goseki, M., Muratsu, K., Mizoguchi, H., Namatame, M., Sugimoto, M., Kusunoki, F., Yamaguchi, E., Inagaki, S. & Takeda, Y. (2013) 'Human SUGOROKU: full-body interaction system for children to learn vegetation succession', In *Proceedings of the 12th International Conference on Interaction Design and Children(IDC2013)*, June, pp. 364-367.

Nakayama, T., Adachi, T., Muratsu, K., Mizoguchi, H., Namatame, M., Sugimoto, M., Kusunoki, F., Yamaguchi, E., Inagaki, S. & Takeda, Y. (2014) 'Human SUGOROKU: learning support system of vegetation succession with full-body interaction interface', In *Proceedings of CHI EA'14- CHI'14 Extended Abstracts on Human Factors in Computing Systems(CHI2014)*, April, pp. 2227-2232.

Yoshida, R., Adachi, T., Muratsu, K., Mizoguchi, H., Kusunoki, F., Namatame, M., Sugimoto, M., Yamaguchi, E., Inagaki, S. & Takeda, Y. (2015) 'Life-size board game "HUMAN SUGOROKU" to teach children about vegetation succession', In *Proceedings of the 7th International Conference on Computer Supported Education(CSEDU2015)*, vol. 2, April, pp. 295-300.