Information Organization of 3-D Landslides Board Game for Ecological Educations

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Abstract. The 3-D board game concentrate on landslide related corresponding components include slopes board, air guns, earth and stone, trees, betel nut trees, dice, event cards, flags. The pre-learning session and simplify the information structure of cards made participant aware its relationship more natural. Simplify the terminology of cards also reduces the complexity of its association. After playing the board game, students are willing to understand more about how things are happening in our surroundings. Virtual experience through the game may help a user to explore the real world in future. The three elements present relationship more precisely and lower the barrier of using in environmental education.

1. Introduction

1.1. Natural disaster
Climate change and over-exploitation caused the natural disaster. Many rainfall-induced severe, large-scale landslides occurred during the last two decades in Taiwan [1]. Catastrophic landslides often happen without warning since the slight topographic creeping is hard to be detected. Recent studies have highlighted the ecological and geomorphological importance of wood debris to forested stream ecosystems [2]. People try to protect channels against the effect of erosion; biomaterials were installed on slopes, channel bed and along river banks [3]. Bioengineering techniques were introduced, and the vegetative check dams were found to be a practical solution for flood hazard minimization [4].

1.2. Environmental education act
The Legislative Yuan passed the Environmental Education Act in 2011 [5]. This law makes people are more environmentally conscious at school and society. People are required to attend four hours of environmental education each year, in the form of lectures, discussions, internships, and group visits. Attractive education facilities have a demand in Taiwan. This study aimed to design the eco-conscious board game including objects and rules. Landslide is a significant natural and sociological event, so we implement this board game to encourage students learning environmental problem through playing.

1.3. Environmental education
Many theoretical frameworks have been developed to explain the gap between the possession of ecological knowledge and awareness, and displaying pro-environmental behavior [6]. Factors included demographic, institutional, economic and cultural factors. The internal factors (such as environmental knowledge, awareness) affect people's attitudes, priorities, and the locus of control. Knowledge and experiences have a stronger inference of people's behavior. Indirect experiences of passive learning
lead to a weaker correlation between attitude and response [7]. The person is familiar with the environmental problem, and its causes will act to lower impact on the environment. People with pro-environmental attitudes are more likely to engage in protective behaviors. The game enables people to experience situations in a virtual environment. Those experiences also extend knowledge domain and bring locus of control [8]. Positive environmental attitudes, ecological sensitivity could be brought into student’s mind through an educational game. Board games with ecology, issues can lead to motivation to approach more related knowledge.

2. Board Game

2.1. Coverage
The board game is favourite in recent years. People stimulate thinking in the interaction between members [9]. Traditionally, board game plays in a 2-D plate. Rules of matches are present to facilitate communications between players. The sensation of fun may derive from mastering new knowledge, skills or experience. In a virtual environment, a player faces set of challenges and generate a personal strategy to win a game [10]. Story and mechanics involve the procedure that provides the structure by which user interacts with system elements. If the controls are not intuitive enough [11], the user will always be distracted by the contradictions. User invest skills to reach the goal and get the pleasure through achieving and confidence [12].

2.3. User interface
By building the environmental content into the game, we can extend student’s learning span. During the playing, users have to concentrate on current situations and practice strategy requires reaching the goal. The user interface is the activities where interactions between humans and machines. The purpose of this communication is to allow efficient operation and control of the apparatus from the human end. For the board game, it included plate, game cards, tools, and the rules that provide information with which a person may interact. The high attraction allows people enjoy playing. Nielsen's mentioned principles for interaction design [13] as follow:
- Strive for consistency: users should not have to wonder whether different words, situations mean the same thing.
- Visibility of system status and offer feedback: The system should keep users informed about what is going on through appropriate feedback.
- Match the real world to yield closure: The system should speak the users’ language.
- Reduce short-term memory load: recognizing something is more natural than remembering it. Minimize the user's memory load by making objects with previous experience.

3. The 3-D Board Game Design

3.1. Concept of design
The 3-D board game concentrate on landslide related corresponding components include slopes board, air guns, earth and stone, trees, betel nut trees, dice, event cards, flags (Figure 1). Designer suggests a suitable age range of users for playing the game is 10-22. Central platform is three-dimensional landscape with a gradient. The typhoons and earth landslide disasters emulated by air-gun and rolling rock (Figure 2). Dolls design reveals their characters, babies wear a raincoat symbolize the animal guards, and attacked rabbit with an escaping posture. Wall construction and tree plant actions emulated people use bioengineering techniques to preserve the land and the animal. Designer implemented the ecological environment theme and response to the situation in cards design. The game progress under driven of random dice (the six sides of the dice) is moving steps and the incidents such as typhoon or earth flow event. When encountered "select event card," player may get trees, Betel nut tree or building development in hillside areas. Players need to think about planting trees or moving dolls to prevent typhoon or landslide rock. Each player has three animals (such as rabbit) and running each rabbit in sequence. The first one moves all doll reaches the target area is the winner.
Figure 1. Eco-run, land conservation board game, where main table field is a curvature 3D structure to emulate the geographic landscape.

Figure 2. (a) Air guns which emulate the disturbing wind in Typhoon, (b) Rock in different size which mimics the rock impact effect in landslide.

Figure 3. The 26 event cards consist of eco-related significant elements: plant, land, and water. The cards contain both positive and negative events which guiding the corresponding action within game.
All contents of the incident cards related to environmental issues (Figure 3) such as golf courses, tourist areas, farmhouses, excessive planting of fruit trees/tea trees, mountain roads extension, destruction of forests, mountain road collapse, stratigraphic sliding and so on. Through the contents of the event card, we bring the player into a different situation. The player can acquire strategy of getting a tree to enhance the ability to sustain in disaster. The use of saplings to avoid air guns and landslide balls are other options. The events and actions prompted the importance of afforestation and soil and water conservation.

3.2. Evaluation-1

Our design aims the beginning level of the environmental education. While prototype constructed, children of different age’s group are invited to play and gather user response. After participants accepted 5 minutes background introduction, the pair of users engaged together in 20 mins playing session. After that, the player filled out a questionnaire. The evaluator also recorded a log of the player’s actions, failures, and coded each of these within observation record. Most of them have a positive feedback. Three of children have difficulty in understanding the content of the cards, so they proceed after evaluator’s explanation. Student’s reflection includes:

- The attractive activities are air gun, landslide, transfer tree, and doll.
- They like absorbing tutorial introduction, but some terminologies are not familiar.
- One student said the game process majorly by random chance.
- Children responses acquired information included: water and land conservation, caring animal and don’t cut the tree from part of gameplay.

3.3. Reflections

Being lacking the beginning level of the ecological knowledge, a player did not have experience of judging the possible choices. Children have difficulty in understanding the content of cards and its relationship, so pre-learn scenarios are required. The script can be a story with the analogy which immerses the audience in imaging situation.

From evaluation-1, we found the game card needs re-organize with a suitable structure that people can follow. The knowledge structure let the student take an appropriate strategy with the environmental situation. The approach determined game process instead of chance. Information re-organization can let player a more comprehensible supporting with fewer instructor involvement.

4. Redesign of the Game Cards

Base on the interface design rules mention above; we modify the design for both logical and visual cognition by matching with user experience and reducing memory load.

Simplifies the cards and its relationship

The KJ method helps people with the right perspectives to reach consensus on priorities of subjective, qualitative data. In cards situation, different option and consequence confuse the player. Proper organizing and prioritizing cards can reduce memory load. The K-J method organizes ideas with following steps:

1. Record each idea on cards or notes.
2. Look for ideas that seem to be related.
3. Sort cards into groups until all cards have been used.

Once the cards have been sorted into groups, the team may classify large clusters into subgroups for easier analysis [14]. In the first step, related or similar cards were combined so that we removed seven cardsd. The 19 remained eco-event cards were grouped as three sub-group (Figure 4).

1. In each sub-group, we characterized as positive and negative effect
2. Try to balance with positive and negative impact in sub-group
3. Another seven cards were added to fulfill the missing element that reflects local problems.
4. Reconnect the cards group with user strategy
5. Re-drawing the cards with graphics icon (Figure 5) to improve the readability
Figure 4. The 21 eco-event cards consist of eco-related elements: plant, land, and water. In a game, a player faces set of challenges and generate a personal strategy to win a game. Story and rules involve the procedure that provides the structure by which user interacts with system elements. During the playing, users have to concentrate on current situations and practice strategy requires reaching the goal and get the pleasure through achieving and confidence. The players build their homeland through the game activities. Two users have a chance to view other side and share their experiences through comparing the difference (Figure 6). The game enables people to experience situations in a virtual environment. Those experiences also extend knowledge domain and bring locus of control and lead to motivation to approach more related knowledge.

Figure 5. The design of 21 eco-event cards.

Figure 6. The event cards of positive (recover) and negative (damage) effects. Players have to concentrate on current situations, and practice strategy requires reaching the goal.
4.1. Evaluation-2
After redesigning the cards, we conducted evaluation-2 for observing: (1) The user interface (game cards, tools, and the rules) allow efficient control of the game. (2) Does the game attractive and allows people enjoy playing. (3) Do users develop personal strategy and react with appropriate feedback? Students of the year-1 group at Chaoyang University are invited to play for gathering user response (Figure 7). The significant differences between Evaluation-1 and 2 are age and knowledge level. We were uncertain about the answer of the young adults. Participants were given background story which describes the living and home country to bring the participant into the scenario.

After the brief introduction, the pair of users engaged together in 20 mins playing session. Then, the player filled out a questionnaire with personal comments. The observer also recorded a log of the player’s actions coded in according to behaviors and emotional responses. Parts of the question are (where two numbers are average, the standard deviation of 5 points measuring scale):

1. Story helped me enter the situation of the board game = 4.416 ± 0.792
2. I found that water, land, forests are closely linked = 4.750 ± 0.452
3. I am willing to participate in the conservation activities = 4.666 ± 0.492
4. Graphic design of the game card, easy to understand = 4.666 ± 0.492
5. Board steps and rules are complicated = 1.333 ± 0.492
6. I like to use air cannon, rolling stones = 4.833 ± 0.389
7. I am willing to play these games again = 4.750 ± 0.452

Most of them have a positive feedback, q6 (air cannon, rolling stones) has the highest score. The results indicated the student welcomed 3-D board and physical interaction. A reverse item was placed in q5 (steps and rules are complicated), the low average score of 1.333 indicates the content of cards is understandable, and the player can practice the game without obstacle. Q7 (willing to play again) also has a high score. The results indicated the 3-D board is enjoyable for young adults.

We extracted essential phrases in the sentence collected from student's comments. A Venn diagram is drawn after the relevant group is counted (Figure 8). The size of the circle represents the strength of the phrase appears, the space between the circles represents its’ relationship.

Figure 7. The students joined evaluation-2.

Figure 8. The user response during evaluation-2 (right: positive / left: negative).
They like absorbing the tutorial story and introduction session. The emotional infiltration and fun expression are high. After cards organization, students send several positive responses on “knowledge extension.” The information structure of water, forest, and land is suitable for learning. The “Icon recognition need improve” shown the consistency between text and graphic led some confusions. Especially, the difficult of “Read the number of dice” comes from new dot pattern. It better uses traditional pattern adapt to with users’ prior experience. “Rock hit probability” and “Doll instability” also need to improve to enhance the credibility. The user’s investigation results correlated with observer recorded log; it provides a high correlation between user and observer. The Pearson correlation coefficient of q2-q3 is 0.816, which is significantly correlated at a level of 0.01 (two-tailed). Question is about (2) knowing the link between water, land, and forests (b) willing to participate in land conservation. Knowledge and experiences have a stronger inference of people’s behavior. Familiar with the problem and its causes support people to engage in protective behaviors.

5. Conclusions
The pre-learning session and simplify the information structure of cards made participant aware its relationship more natural. The storytelling and internal structure of the problems are used in the beginning. Simplify the terminology of cards also reduces the complexity of its association. After playing the board game, students are willing to understand more about how things are happening in our surroundings. The virtual game activities build a mutual connection with the real world. The game involves users in a specific situation and gains thinking by making own strategy, so that virtual experience through the game may help a user to explore the real world in future. More precisely knowledge structure need acquire from expert to extend the confidence of their correlation. The three elements interaction (land, water, and forest) can extend to present relationship more precisely. The adjustment of the board game can lower the barrier of using in environmental education.

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