Developing a Recipe planning Board Game by Design Thinking Approach

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Abstract: Game-based learning has been proven to be an attractive learning model by many studies, but the effectiveness of game-based learning could be limited if the game is not properly designed in consideration of domain knowledge and learning strategies. In this study, we develop a recipe planning board game using the board game design assisted system and board game tool kit to incorporate with the recipe knowledge. In the 2019 winter camp held in Asia University, a total number of 64 primary students participated in a game-based learning course for healthy eating courses. The experimental results showed that the proposed board game learning process was useful and easy to use.

Keywords: Recipe planning board game, Learning by doing, Game-based learning, Design thinking

1. Introduction
In recent years, due to the medical and health science progress, the elderly population is increasing rapidly. Therefore, proper diet and proper exercise are becoming more and more important for people to keep better health condition. [1-3]

As we know, through the "game-based learning" strategies, students are encouraged to actively participate in the learning activities, and then they can not only easily learn the content embedded in the game but also make new friends via social communication. For example, board games including strategy games, family games, battle games, and puzzle games have received more and more attention in the past few years. In particular, board games using cards are even more popular. However, designing a board game integrated with both some specific learning domain and the entertainment purposes is a challenging task due to requiring innovation, relevant domain knowledge and experience.

To help people easily learn the concepts of the balance nutrition diet, in this paper, we develop a recipe planning board game by the design thinking approach. To facilitate the development, we used the board game design assisted system with the board game tool kit [13] in consideration of the outline of the healthy diet habits of the 12-year national education curriculum [15-16]. In 2019, we firstly developed the recipe planning board game, and then the elementary students played it to convey the correct diet concept in the winter camp held in Asia University. The result shows that the students can learn the knowledge of cooking and the recipe planning to know the balance diet concepts after playing the game.

2. Related Works
Game-based learning
Nowadays, many effective game-based learning methods or tools have been successfully applied to different teaching courses in various domains [3-4]. The application of game-based learning is not only useful for students to acquire knowledge content and improve social skills, but also helpful for them to enhance their motivation and interest in learning.

Design Thinking
Design thinking starts by drawing a theme based on the needs of students, then helps them to create new ideas or new elements to enhance the theme, and finally helps them to complete the whole design. In other words, design thinking is a cognitive process from the step of design through the steps of decision-making, discussion, creativity, prototyping, testing, etc. Therefore, students can get inspired through the way of adding/removing some element in/from
the game, which the students already played [5-10]. The design thinking has been successfully applied to solve complex problems via creative thinking in the design, business, engineering, and education fields [11-12].

In [13-14], the design thinking spiral-modeling method was proposed to facilitate the board game design, in which four steps have to be iteratively executed to refine the design process, as shown in Fig 1.

![Figure 1. Design Thinking spiral modeling](image1)

**Step 1. Select the target and theme:**
Firstly, the recipe planning board game was selected.

**Step 2. Refer to Monopoly Games and Discussion**
By referring to the “Monopoly” board game, which is to accumulate money by buying and trading properties [17], the board with a map can increase the flexibility and joyfulness of the game.

**Step 3. Make the recipe planning game rules and cards**
According to the background story, education purposes and gameplay, we design the game rules and prototype of the game including the character cards, skill cards, and situation cards.

**Step 4. Testing and modification**
This step is to check the game rules for consistency and joyfulness. The above steps will be repeatedly executed until the board game has been well tested and adjusted to guarantee the game is meaningful and interesting.

**Board game design assisted system**
Based on the above spiral design process, the board game design assisted system together with the board game tool kit proposed in [13-14], as shown in Figure 2, has been used to design the desired board game to not only improve the effectiveness of students’ learning, but also enhance their effectiveness of creativity. Before using the board game design assisted system, we prepare the required input of the board game, including knowledge map, game maps, game roles and game rules.

![Figure 2. Board game design assisted system](image2)

3. **Our method**

In this section, we will introduce how to prepare the required input of the board game design assisted system to develop the recipe planning board game.

We firstly design the knowledge representation of the related teaching material, and then design the game rules according to the Ministry of Education’s 12-year education curriculum focusing on the teaching of healthy diet, the basic concepts of health knowledge, and healthy behaviors [16]. Playing the recipe planning board game is to help the kids build a health behavior for self-health management.

**Knowledge map:**
We further design the knowledge map of recipe planning board games, which is basically a three-layer healthy diet ontology describing the relationships between the basic health diet ingredients.

The first layer introduces the four main dietary categories: grain, seafood, meat, and fruits/vegetables. The second layer partitions each category into several sub-categories, and third layers provides basic ingredients for recipe planning board game. For example, wheat belongs to the grain, and has noodles and flour.
Game map:

Game maps can be divided into static maps and dynamic maps. If the map is fixed during the game playing, then it is a static one; otherwise, it is dynamic. We adopt static map because it is easier for incorporating the domain knowledge and design.

As we know, the Monopoly map is a unidirectional cycle. In our map, there are four areas with different colors, representing different four types of main dietary categories. The orange color represents the grains, the blue color represents the seafood, the red color represents the meat and the green color represents the fruits/vegetables. Besides, a variety of different situations, traps, theme courses, and kitchens are included to enhance the learning content. Therefore, the players take turns to throw a dice, and then decide to move forward, backward, left-turn, or right-turn to increase the game’s flexibility.

Game role:

During the game design, we used the accessories of the board game consisting of six different colors of cards to represent different storyboards, scene cards, or special cards to increase the knowledge level, randomness and joyfulness of the game. After repeatedly testing and adjusting, the roles include Taiwanese chef, Japanese chef, Korean chef, American chef and French chef each with the corresponding type of skill, as shown in Table 1. Players who act as the cooking role can use the corresponding chef skill to cook the selected menu to increase the chance of win.

Game rules:

At the very beginning, players must select at least four dishes to cook from the recipe planning table, and then these dishes will be checked whether the basic requirements about nutrition and health are satisfied. For example, choosing more than three dishes with meat to get high scores is not allowed because it is most likely not good for health. Similarly, the rules of the game need to be repeatedly tested and modified to achieve the consistency and joyfulness of the game.

The knowledge and the game rules of the recipe planning

Many different dishes with different nutrition are provided for reference, so that players can not only learn the recipe planning, but also learn the concept of diet health and nutrition after the game playing. Besides, the more difficult it is to cook the dishes, the higher the score.

As shown in Table 2, Scores consist of 1, 2, 4, 6, and 8. If players choose ingredients that are easier to cook, they will get lower scores. Therefore, if a player cooks one dish of score 1, one dish of score 4, and two dishes of score 8, he/she gets 21 points in total and will win the game. In Table 3, the dishes are with blue, red, and green colors representing seafood, meat, and fruits/vegetables, respectively. Accordingly, the four dishes chosen will be checked whether the dishes’ ingredients are balanced.

Table 1. The relationship between the roles and ingredients

<table>
<thead>
<tr>
<th>Role</th>
<th>Taiwanese chef</th>
<th>Japanese chef</th>
<th>Korean chef</th>
<th>American chef</th>
<th>French chef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game skills</td>
<td>Cooking rice</td>
<td>Cooking noodles</td>
<td>Cooking seafood</td>
<td>Cooking meat</td>
<td>Cooking cheese</td>
</tr>
<tr>
<td>Ingredients</td>
<td>Rice</td>
<td>Noodles</td>
<td>Seafood</td>
<td>Meat</td>
<td>Cheese</td>
</tr>
</tbody>
</table>

Table 2. Ingredients cooking and score table

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>score</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

\[
(1 \times 1) + 0 + (1 \times 4) + 0 + (2 \times 8) = 21
\]

Table 3. The recipe ingredient table
In this paper, the knowledge frame is used to describe the relationships between the concepts of recipe and the game cards, including the knowledge of the collected relevant recipes, cooking concepts, and the suggestions of the chef experts. The rules of the game are shown in Table 4.

Table 4. Recipe planning board game rules

<table>
<thead>
<tr>
<th>Rules</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1</td>
<td>Before playing the recipe planning board game, each player must describe his plan including 4 dishes to be cooked.</td>
</tr>
<tr>
<td>Rule 2</td>
<td>The players take turns to throw the dice, and then take the same number of moves as the dice appears. (Since the map is undirected, the player can go in any possible direction of the game map every move.)</td>
</tr>
<tr>
<td>Rule 3</td>
<td>If the player stops at a question mark cell on the map, then he/she will get a trap or situation card. (The situation card will be chosen randomly to increase the fun of the game.)</td>
</tr>
<tr>
<td>Rule 4</td>
<td>If he/she defeats the monster then he/she will get one more food card; otherwise, all the gotten food cards will be eaten by the monster.</td>
</tr>
<tr>
<td>Rule 5</td>
<td>If the player stops at a kitchen cell with the required food cards for a dish, then he/she can cook the dish and get the corresponding score.</td>
</tr>
<tr>
<td>Rule 6</td>
<td>If one player has cooked all the four proposed dishes with the accumulated score greater than 20, then he/she will win the game.</td>
</tr>
</tbody>
</table>

The recipe planning board game contains 11 sub-categories of ingredients. During the board game playing, if a player won by cooking dishes with a variety of different ingredients, we assume he/she could understand the importance of healthy diet.

4. Experimental Design of the Recipe Board Game

As shown in Figure 5, the experimental design process includes six steps: the experimental grouping, healthy diet course teaching, pre-course testing, board game teaching, post-course testing, and concept analysis and discussion.

To evaluate the performance of our approach, a three-session experiment with 90 participants was held in the 2019 Winter Camp in Taichung, Taiwan, where each session lasts one and a half hours. Due to the different grades of students having different learning and comprehension abilities, they are partitioned into three groups. Each group has five people. The diet course content has been designed based on the Ministry of Education k-12 the healthy diet-related curriculum and its related knowledge. With the easy-to-understand game rules and rich learning content, students can learn knowledge and learn the importance of food ingredients and healthy diet by game-based learning.

Concept map learning about healthy diet

As shown in Table 5, there are three different kinds of healthy diet concepts indicating that the students have to understand the knowledge in each aspect. At the end of the experiment, a post-test consisting of several quizzes embedded with the healthy diet concepts...
was conducted. Remedial learning based upon the concept map was further applied to improve the misconceptions of students.

Table 5. The conceptual description of the recipe planning board game concept.

<table>
<thead>
<tr>
<th>Healthy diet concept</th>
<th>Learning health cognition concept</th>
<th>Learning health diet situations and skills concept</th>
<th>Health behaviors concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>The three meals normal.</td>
<td>Chew food thoroughly and swallow it slowly</td>
<td>Low salt, low sugar, and low oil.</td>
<td>Finish wash the dishes, and need to dry.</td>
</tr>
<tr>
<td>Chowing habit.</td>
<td>Keep exercising habits.</td>
<td>Much water, many vegetables and fruits, and many grains.</td>
<td></td>
</tr>
<tr>
<td>Don’t eat fresh meals.</td>
<td></td>
<td>Dumping scrap food every day.</td>
<td></td>
</tr>
<tr>
<td>Low salt, low sugar, and low oil.</td>
<td></td>
<td>Check stale foods in refrigerator.</td>
<td></td>
</tr>
</tbody>
</table>

According to the student’s pre-test scores shown in Fig. 6, we found that in the pre-test only 7 students got the full score, while in the post-test 64 students got the full score. It shows that the proposed approach is useful for students learning.

Figure 6. The distribution of students’ pre-test and post-test scores

According to the game satisfaction survey, shown in Figure 7, 92% of students felt interesting to learn healthy diet courses. Through the questionnaire feedback, the students proposed suggestions including the modifications of the game rules and the unclear domain knowledge. These will benefit our subsequent modifications and adjustments.

Figure 7. The recipe planning board game satisfaction survey

5. Conclusion

In the paper, we developed a recipe planning board game by using board game assisted system. In addition, the domain knowledge of recipe planning and the learning strategies have been incorporated into the game design. According to the recipe planning board game experiment held at the 2019 Winter Camp, the students’ learning performance have been improved significantly.

Acknowledgement

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