

## Through Games, Discover the word

Games accompany our growth. In games, we can unconsciously learn knowledge about natural sciences, cultures and common sense of life. Well-designed games also help to train our analytical ability and to communicate with people, which could be a beneficial complement to our school education.

Game design may involve many fields of sciences, such as pedagogy, psychology, mathematics and aesthetics. In order to design a game, we need to firstly analyze the target groups and ages, define the expected training objective, and then study the related rules.

We have a game called “Wonder Island”, see Fig. 1. This game is designed for children above six years old aiming at training the sense of permutation and combination, spatial position and neighboring relations, logic reasoning, etc. We can see from Fig. 1 that the game is based on a 3D map of an island. There are sixteen small blocks representing animals, including one elephant, one monkey, one tiger, one pig, one cat, one turtle, two hippos, three lions and five pandas. The 3D island is divided into 3-by-3 grids containing three rows and three columns. The grids on each row and each column correspond to a fruit - say, apples, mangos and oranges for the rows and pineapples bananas and strawberries for the columns, for instance. Or for entertaining we say the animal to be placed in a grid can eat the fruit on the corresponding row and column. Each time the players are required to place nine blocks on the map. How to place the blocks depends on given conditions/rules.



In order to be entertaining and non-frustrating, the game is usually divided into different levels accord to their difficulty level. In the following, four examples are presented to show the conditions and the corresponding solutions with increasing difficulty.

The first level is shown in Fig. 2. Level ten is show in Fig. 3. Fig. 4 shows level thirty-three. Level fifty is presented in Fig. 5.

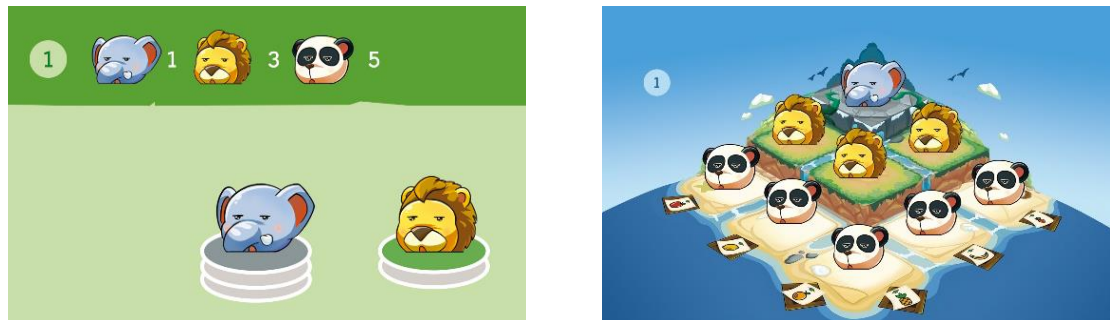


Fig. 2. Level 1.

The restrictive conditions are given on the left. It says that we need to place one elephant, three lions and five pandas on the map. And the elephant must be placed on the highest grid and the lions must be placed on the second-level grids. The solution is given on the right.

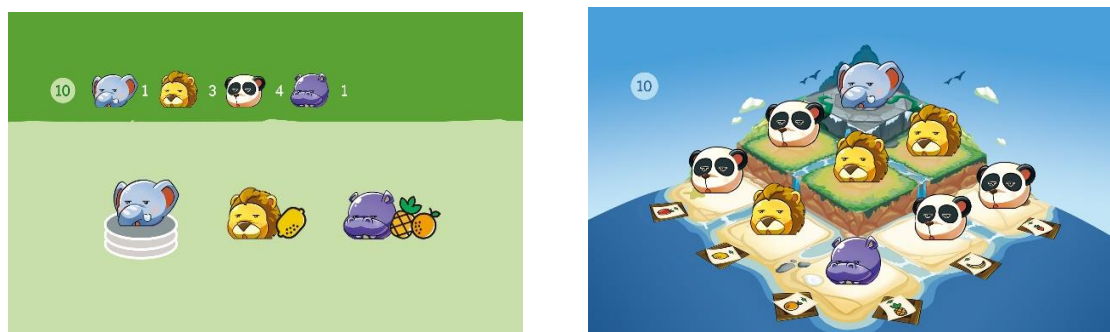


Fig. 3. Level 10.

The restrictive conditions are given on the left. One elephant, three lions, four pandas and one hippo are to be placed on the island. The elephant goes on the highest level, all the lions can eat lemons, and the hippo can eat pineapples and oranges. The solution is given on the right.

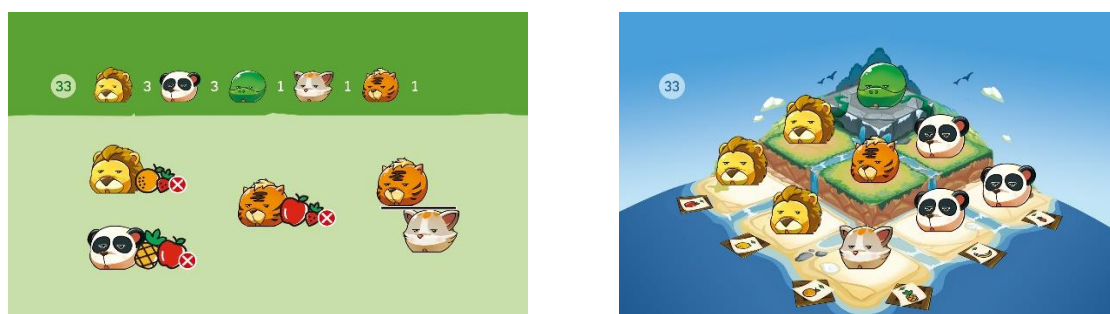


Fig. 4. Level 33.

The restrictive conditions are presented on the left. Three lions, three pandas, one turtle, one cat and one tiger are to be placed on the map. Lions cannot eat neither oranges nor strawberries, pandas cannot eat neither pineapples nor apples, tigers cannot eat neither apples nor strawberries, and lions must go above the cat. On the right, we have the solution.

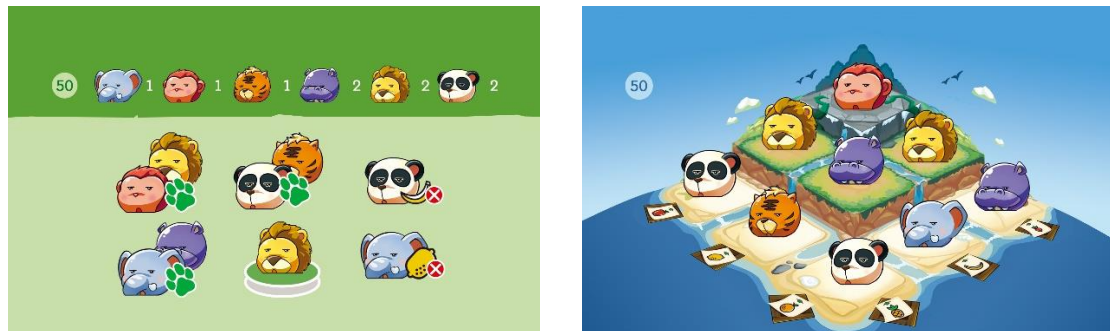


Fig. 5. Level 50.

The restrictive conditions are on the left. We are required to place one elephant, one monkey, one tiger, two hippos, two lions and two pandas on the map. Lions must be the neighbors of the monkey, the hippos must be the neighbors of the elephant, the pandas must be the neighbors of the tiger, the lions go on the second level, the panda cannot eat bananas and the elephant cannot eat the lemons. The solution is given on the right.

The difficulty of a game is usually related to the size of the map (number of grids), number of levels of the grids, number of the types of the animals and the number of the animals of each type, and allowing, and the number of allowable and restrictive conditions, etc.

### Problem:

- I. Develop a mathematical model to measure the difficulty of a game like Wonder Island. And explain why your model is reasonable.
- II. Develop a mathematical model or an algorithm to determine if there exist solution(s) under the given restrictive conditions. Is the solution unique?
- III. Design a game like Wonder Island based on your models and analysis above.
- IV. Write a 1-2 page memo of promotion for your game summarizing your results.