

Article

Design and Evaluation of a Board Game in Food and Nutrition Education

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Abstract: The outbreak of the COVID-19 pandemic has caused increasing concern over health care, part of which involves the role of nutrition. In this study, a nutrition educational board game, featuring quantitative computation, was designed to help students acquire nutrition knowledge and improve dietary behaviors. A group of 22 students in grade 7 of a middle school in Beijing were selected as the participants. A single-group pre- and post-test quasi-experimental design was adopted. Knowledge-Attitude-Practice (KAP) questionnaires and interviews were used to investigate students' changes in dietary knowledge, attitude, and behavior. The influence of gender and body mass index (BMI) on the teaching effectiveness was also explored. The results showed that some dimensions of knowledge, attitude, and behavior significantly increased in the students. Their changes in behavior were mainly related to some aspects that were easier to adjust. In addition, the study also found that females and students with abnormal BMI were more likely to be influenced by the educational game to make positive changes in attitude and behavior.

Keywords: nutrition education; board game; knowledge-attitude-practice



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1. Introduction

Adolescence is a critical period of growth and mental development. Balanced nutrition intake and dietary behaviors play an important role in healthy growth and prevention of various chronic diseases. However, the incidence of obesity is increasing in recent years [1], which is mostly due to irregular diet structure, bad eating habits such as not eating breakfast, deficient intake of vegetables and coarse grains, and decreased physical activities [2].

Adolescence is also a crucial period for cultivating good eating attitudes and behaviors, which depend on mastery of good food knowledge [3]. However, there is not a special curriculum on food nutrition in primary and middle schools in China, and students can only acquire a little knowledge in science courses [4]. Primary science curriculum standards specify that students learn the basic concepts of nutrients and energy. Secondary chemistry curriculum standards specify that students learn the function of some nutrition organic compounds (carbohydrates, starch, protein, vitamins, and so on), mineral elements (calcium, iron, zinc, and so on), and poisonous compounds in their third year in middle school. Secondary biology curriculum standards specify that students learn how nutrients are digested and absorbed in the body. The knowledge in primary school is too shallow for students and they start learn deeper content too late. Additionally, although the government has provided some documents such as “guidance outline of health education in primary and secondary schools”, the items are not quite explicit and a number of schools do not take them as key content in normal classes. Some schools, especially those in remote

areas, suffer from desperate shortages of professional teachers; instead, nutrition knowledge is taught by teachers of other disciplines [5]. The above points are all reasons why schools did not provide favorable conditions for students to master good nutrition knowledge.

In recent years, many researchers have used educational games to assist traditional teaching in order to enhance students' interest in active learning and improve teaching effectiveness [6]. Chen et al. investigated the time effect of cooperative games such as cards, board games, and riddles on students' emotions of learning science and found that games helped to maintain students' positive emotions. Another study [7] designed a serious game in the area of nutritional knowledge to test its effect on children and discovered it was an adequate educational tool. The researchers in [8] explored the gamification as a teaching strategy in the pandemic years and concluded that it increased students' motivation and engagement and improved their attitudes [9].

Among various education games, the board game has a long history, fewer adverse effects, lower development costs, and better experience. In general, it has following advantages: (1) It can improve students' learning motivation [10]; (2) It is easy to combine multiple disciplinary content and improving students' interdisciplinary ability; (3) When used in multiplayer format, it can enhance students' language performance and communication ability; (4) The physical attributes of the board game can enhance students' sense of immersion and leave them a deeper impression of knowledge [11].

However, although there are many board games in the market, most lack the guidance of teaching theories and are not suitable for class teaching. Some educational games designed by researchers such as chemical pokers [12] are mainly directed at young children, which gives priority to increasing learning interest with less emphasis on subject education. In some countries such as Turkey, Australia, and New Zealand, board games have been widely developed and used in primary and middle schools with multiple themes, including not only traditional subjects but also human and science topics like planets [13], first aid [14], health education [15], chemistry [16], creative problem-solving skills [17], and so on. Evaluation studies have been conducted by many researchers. In contrast, board games are deficient in health and food topics in China and empirical studies are few.

This research attempts to employ game-based learning theory by developing an interesting game situation and interaction mechanism to intrigue students' intrinsic motivation. Specifically, it tries to integrate STEM elements, particularly the knowledge of chemistry and nutrition, with daily education through a board game with the purpose of helping students to learn food nutrition in a fun environment. Students are expected to have a positive change in attitude and behavior after they finish the board game. The degree of change may vary for students of different gender and weight, as previous literature has suggested that girls are more concerned about body image than boys [18], and there was a strong relationship observed between body image dissatisfaction and body mass index (BMI) [19]. It is assumed that students of different gender and weight will exhibit different degrees of eagerness to obtain nutrition knowledge and change dietary habits. Therefore, the research questions are as follows:

1. What impact will board game have on students' nutrition knowledge, dietary attitude, and behaviors?
2. Are there any differences in the effects of a board game on students of different gender and BMI?

2. Materials and Methods

This study intends to integrate a board game with chemistry lectures and thus allow the adoption of a single-group pre- and post-test quasi-experimental design to find whether the students can adapt and what effect the board game will have on them in the cognitive and affective domains.

2.1. Participants

A group of 22 students (8 females and 14 males, aged 12–13, from the same class) in grade 7 of a middle school in Beijing were selected as the participants, whose profiles and body index (BMI) can be found at Table 1.

Table 1. Basic profiles of participants.

	Low BMI	Normal BMI	High BMI
Male	8	3	3
Female	2	6	0
Total	10	9	3

2.2. Study Methods

The activities were carried out for 6 weeks, 1–2 times per week and 30 min per time. One day before and after the program, questionnaires were used in pre- and post-test. A month after the program, an additional test was carried out to evaluate students' attitude and behavior. In addition, six students were randomly selected to join a semi-structured interview at the end of the program.

2.3. Study Instruments

2.3.1. The Introduction of the Board Game

This board game has 90 checks, including food check, sports check, treasure box, supermarket, hospital, testing station, food problems tasks, and so on. Students need to move their pieces along the checks in turns by throwing the dice and collect food cards or drawing task cards in certain checks. The final goal is to acquire more healthy food according to the food pyramid and standards of basic energy metabolism.

The teaching goals are as follows:

1. Knowledge: understanding and mastering the relationship between seven nutrients and food, nutrient function, nutrient deficiency, food safety, food pyramid, healthy diet structure, unhealthy dietary habits, and food labels;
2. Attitude: recognizing the importance of healthy diet, increasing self-efficacy, and being more willing to adjust their eating habits;
3. Behavior: changing eating frequency of different types of food, adjusting dietary structure, and utilizing nutrition reference information such as food labels.

The game set, as Figure 1 shows, is comprised of following parts:

The game map;

1. Food pyramid card: it has five floors, listing daily recommended intake of different type of food. It is the reference of food selection and grades accounting;
2. Food card: 50 kinds of common food, including meat, egg, dairy, vegetables, fruits, grains, and puffed food;
3. Treasure box card: eight kinds of function, including skip, pass, acceleration, cooking, exchange, stealing, transfer, and adding food;
4. Food problem card: eight kinds of tasks, including calcium deficiency, iodine deficiency, iron deficiency, vitamin A deficiency, vitamin B deficiency, vitamin C deficiency, food deterioration, and food poisoning. Students need to draw out one card and complete tasks on it;
5. Testing station: six kinds of nutrients, including protein, fat, carbohydrate, fiber, sodium, and high GI (glycemic index) food. Students need to check whether their total amount of a nutrient fit the standard.



Figure 1. The sketch of the board game set.

2.3.2. Game Rules

It is suggested that 3–5 students play the game together. Boys set the basic energy metabolism rate as 1400 kilocalories per day and girls set it as 1200 kilocalories per day. They then throw the dice to move their pieces on the board and complete corresponding tasks. The detailed procedures can be seen from Figure 2, as explained in the following:

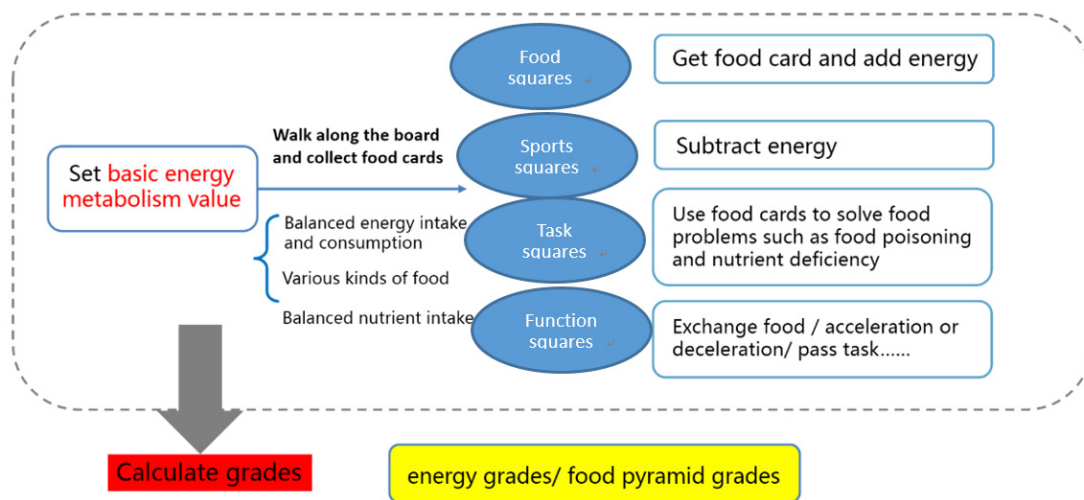


Figure 2. The sketch of game rules.

2.3.3. Game Designing Principles

First, based on the key points in the literature review, this game involves two elements: quantitative thinking and more operational knowledge. During the process of energy calculation and dietary pyramid calculation, students need to remember the energy and nutrient value of different foods, which helps them to deepen memories; when stepping into task checks, they need to solve problems on the food cards they have collected, which amounts to the utilization of the knowledge, helping them to establish linkages between theories and reality.

Second, according to the food pyramid, it is suggested to eat a higher proportion of vegetables and less meat, but there are more meat and high-fat food checks and fewer vegetable and fruit checks on the board. Therefore, students need to use strategies to acquire more healthy food cards and abandon unhelpful cards.

Third, some food task checks set punishment for going backwards, helping students to strengthen awareness of avoiding some unhealthy dietary habits, such as unreasonable dietary structure and unbalanced intake of nutrients.

Last, the final grades contain multiple dimensions, which requires students to think more and use more strategies and knowledge. “Speed grades” are designed for entertainment. “Energy grades” are intended to test whether students can consider the energy intake in an overall view. “Food pyramid grades” are designed to test whether students mastered the balanced intake of different types of food.

The professional part of the game refers to teaching materials of food nutrition [19], and the content has been checked by associate professor Chen Yanhui of food science and nutrition engineering college at China Agricultural University, so the game can be guaranteed to be scientific.

2.3.4. Questionnaires

The questionnaires used in pre- and post-test have four parts: basic information, nutrition quiz, dietary attitude scales, and behavior scales.

Basic information includes name, gender, height, and weight (for the calculation of BMI).

Food nutrition knowledge comprises three parts: food and nutrient (nine questions), food pyramid and dietary structure (three questions), and food safety and package (three questions), 15 questions in total. All questions refer to the literature of An [20], Zhao [21], and national nutritionist exam questions. The proportion of different parts of knowledge points corresponds to their distribution in the game.

Dietary attitude questions are in the form of Likert scales, nine items in total, which comprise three dimensions: the awareness of the importance of healthy diet, self-efficacy of the command of nutrition knowledge, and the willingness to adjust dietary behaviors. All items are adapted from the research of Turconi [22]. The Cronbach’s alpha value ranges from 0.773 to 0.8.

Dietary behavior questions contain food intake frequency scales (11 items) and Likert scales (seven items). All items are adapted from the research of Anderson [23]. The Cronbach’s alpha value ranges from 0.794 to 0.818.

2.4. Implementation Schemes

As can be seen from Figure 3, students were divided into six groups (3–4 students in one group) to play the game. Each activity lasted about 30 min. In the first five activities, a tutor led students to discuss playing skills based on certain topics in the first 10 min, as can be seen from Table 2. And the difficulty of the game would be increased step by step, during which the knowledge points were delivered to students in a more interesting way.



Figure 3. Photos of game activities.

Table 2. Discussion topics.

	Topics	Contents
The first time	Why do people eat food?	1. Seven kinds of nutrients 2. How to intake and consume energy
	The introduction of game rules	1. Three final goals of the game 2. Grades calculation
The second time	How to choose food?	1. Energy balance 2. Food pyramid 3. How to use functional cards
The third time	How to avoid punishment?	1. Unhealthy dietary habits 2. How to avoid nutrient deficiency 3. How to challenge “examination station” part
The fourth time	How to avoid punishment?	1. Food spoilage and food poisoning
The fifth time	Paying more attention to food cards	1. How to read food labels 2. GI values

2.5. Data Analysis

SPSS 19.0 was used for data analysis. Due to the small sample size, Wilcoxon rank test was used in the analysis of the teaching effect of the board game. The Mann–Whitney rank sum test was used to analyze the differences of learning effects among students with different gender and physical indicators.

3. Results

3.1. Students’ Change in Knowledge, Dietary Attitude, and Behavior

Food nutrition knowledge test contains three parts: food and nutrient, food pyramid and dietary structure, and food safety and package, with grades of 14 points, 4 points and 5 points, 23 points in total. As can be seen from Table 3, students’ total knowledge grades increased significantly after the 6-week intervention. In specific knowledge points, students had significant increases in two dimensions: food and nutrients and food safety and package. Most students had better command of nutrient deficiency, what food contained high level of nutrients, and food pyramid structure. In contrast, for some questions that needed comparison (e.g., which of the following foods has the highest calorific value?) and questions about GI that had lower prevalence in the game, students showed less improvement.

Table 3. Students’ changes in nutrition knowledge.

	Pre-Test	Post-Test	Z Value
Food and nutrients	6.09 ± 2.54	7.32 ± 3.11	1.99 *
Food pyramid and dietary structure	1.00 ± 0.92	1.77 ± 1.31	1.97 *
Food safety and package	2.18 ± 1.47	2.50 ± 1.33	0.93
Total grades	9.27 ± 3.11	11.59 ± 4.25	2.25 *

Note: * $p < 0.05$.

Dietary attitude scales contained three dimensions: the awareness of the importance of a healthy diet, self-efficacy of the command of nutrition knowledge, and the willingness to adjust dietary behaviors. As can be seen from Table 4, students significantly increased scores in importance awareness and self-efficacy, but there were no significant changes in willingness to adjust.

Figure 4 shows students’ intake frequency of different types of food before and after the game activities. Breakfast, fruits, vegetables, milk, eggs, and coarse grains are recommended for higher intake frequency (every day); candy, puffed food, sugary drinks, and fast food, which have little nutritional value, are recommended for lower intake. As can be seen from the Figure 4, students already had a relatively reasonable dietary structure. Approximately 80% of students had breakfast, fruits, and vegetables more than 5 days per week. Among recommended food, eggs and coarse grains were two kinds of food with

relatively low intake frequency. More than 60% of students ate candy, puffed food, and fast food less than 2 days per week. Among not recommended food, sugary drinks had higher intake frequency.

Table 4. Students' change in dietary attitude.

	Pre-Test	Post-Test	Z Value
Awareness of healthy diet	3.98 ± 1.01	4.30 ± 0.81	2.21 *
Self-efficacy	3.63 ± 0.76	4.04 ± 0.80	2.07 *
Willingness to adjust	4.24 ± 0.85	4.53 ± 0.57	1.39

Note: * $p < 0.05$.

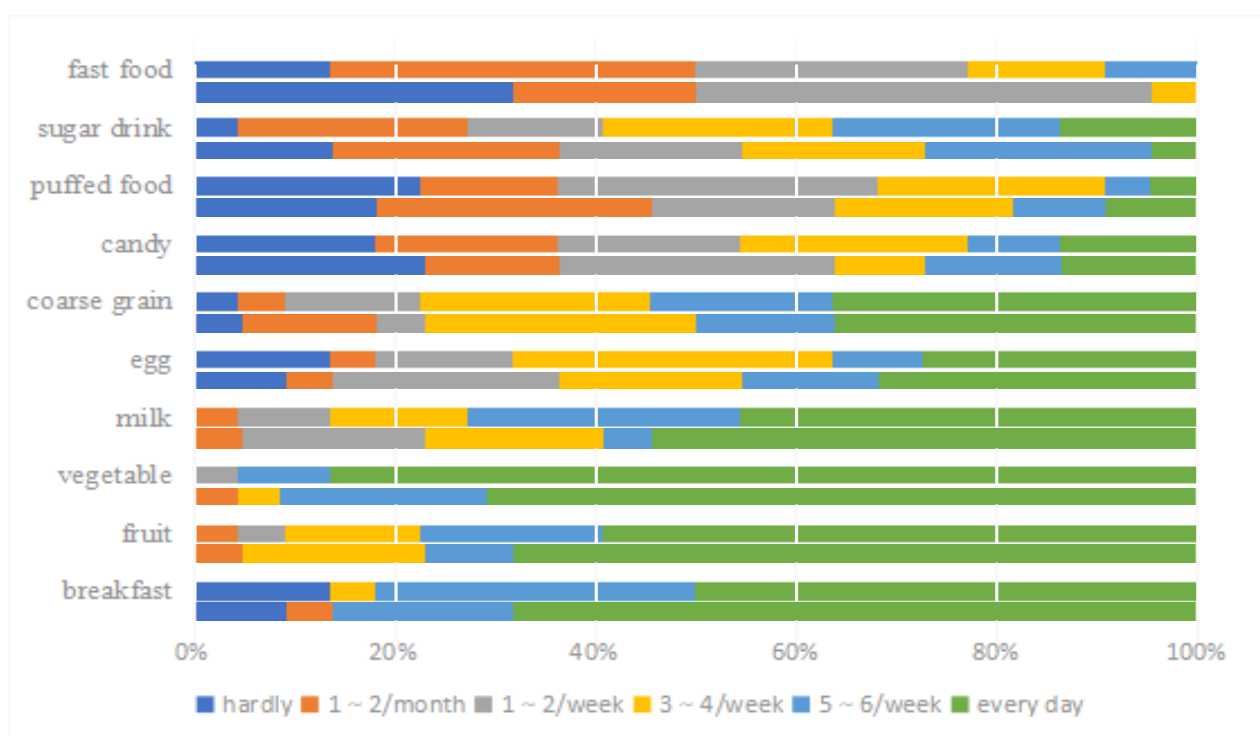


Figure 4. Intake frequency of different types of food in pre- and post-test. Note: for the same kind of food, the upper stripe shows pre-test result and the lower stripe shows post-test result.

After the 6-week intervention, the number of students who ate breakfast and fruit with higher frequency had increased. For vegetables, the number of students who ate it every day had decreased, but the overall change was not large. For milk, there was a small increase in the number of students who drank it every day or with low intake frequency. The number of students who ate eggs with higher frequency increased. There was little change in the intake of coarse grains. Among food not recommended, the average intake frequency of sugary drinks and fast food had decreased. The intake frequency of puffed food and candy had only a slight fluctuation.

Dietary behavior scales contain three dimensions: balanced intake of nutrients (students make some food pairing adjustments between meals to achieve balanced intake of nutrients), food intake frequency (students increase the intake of recommended food such as fruits and vegetables and reduce the intake of not recommended food), and reading food labels (students pay more attention to food labels when buying goods).

As can be seen from Table 5, students significantly increased their scores in food intake frequency and reading food labels, which corresponded to the result of Figure 4 to some extent.

3.2. Students' Change in Delay Test

The delay test was designed to investigate whether students' attitude and behavior would be further improved over time. In terms of attitude, there were not significant changes in the scores of the delay test compared with the post-test. However, students' scores of willingness to adjust (4.61 ± 0.64) were significantly higher than those in the pre-test ($Z = 2.32, p < 0.05$). In terms of behavior, there were not significant changes in scores of balanced intake of nutrients and food intake frequency between the delay test and the post-test. Scores of reading food labels (4.09 ± 0.75) had significant decrease compared with those in the post-test ($Z = 2.71, p < 0.01$).

Table 5. Students' change in dietary behavior.

	Pre-Test	Post-Test	Z Value
Balanced intake of nutrients	3.77 ± 1.20	4.25 ± 0.78	1.36
Food intake frequency	4.21 ± 0.91	4.59 ± 0.63	2.17 *
Reading food labels	3.82 ± 1.05	4.50 ± 0.67	2.68 **

Note: * $p < 0.05$, ** $p < 0.01$.

3.3. Difference in the Effects of Board Game on Students with Different Gender and BMI

Due to the small sample sizes after the split of all students, there may be some error in the analysis. As can be seen from Table 6, there was no significant difference in knowledge scores between boys and girls. In terms of willingness to adjust, only girls had significant increasing scores, with little change on the level of all students. In terms of other dimension of attitude and behaviors, boys and girls had different changes. In the dimension of importance awareness and food intake frequency, only girls had significant improvement. In the dimension of self-efficacy, only boys had significant improvement.

Table 6. Differences in the effects of board game on students with different gender.

		Male			Female		
		Pre-Test	Post-Test	Z Value	Pre-Test	Post-Test	Z Value
Knowledge	Food and nutrients	5.71 ± 2.58	7.21 ± 3.02	1.57	6.75 ± 2.49	7.50 ± 2.46	1.51
	Food pyramid	1.07 ± 0.99	1.71 ± 1.33	1.31	0.88 ± 0.84	1.88 ± 1.84	1.54
	Food safety and package	1.71 ± 1.33	2.29 ± 1.33	1.21	3.00 ± 1.41	2.88 ± 1.35	0.18
Attitude	Importance awareness	4.16 ± 0.73	4.26 ± 0.84	0.92	3.66 ± 1.39	4.37 ± 0.81	2.03 *
	Self-efficacy	3.69 ± 0.75	4.29 ± 0.64	2.14 *	3.54 ± 0.82	3.62 ± 0.92	0.37
	Willingness to adjust	4.45 ± 0.67	4.52 ± 0.62	0.12	3.87 ± 1.04	4.54 ± 0.50	2.03 *
Behavior	Balanced intake of nutrients	3.92 ± 1.31	4.35 ± 0.74	0.80	3.50 ± 1.00	4.06 ± 0.86	1.29
	Food intake frequency	4.55 ± 0.59	4.71 ± 0.64	1.26	3.62 ± 1.09	4.37 ± 0.60	2.00 *
	Reading food labels	4.14 ± 0.86	4.71 ± 0.61	2.00 *	3.25 ± 1.17	4.13 ± 0.64	1.99 *

Note: * $p < 0.05$.

According to BMI standards, normal BMI ranges from 18.5 to 24. A BMI of more than 24 means overweight, and a BMI of less than 18.5 means underweight. Students were divided into two groups: normal BMI group (9 students) and abnormal BMI group (13 students). As can be seen from Table 7, the abnormal BMI group had significant increasing scores in multiple dimensions, including self-efficacy, food intake frequency, and reading food labels, whereas there was little change in the normal BMI group.

In the pre-test, scores of self-efficacy in the abnormal BMI group were significantly lower than that in the normal BMI group ($z = 2.31, p < 0.05$), and scores of willingness to adjust were significantly higher ($z = 1.98, p < 0.05$).

Table 7. Differences in the effects of board game on students with different BMI.

		Normal BMI			Overweight and Underweight		
		Pre-Test	Post-Test	Z Value	Pre-Test	Post-Test	Z Value
Knowledge	Food and nutrients	6.89 ± 2.52	7.44 ± 3.64	0.74	5.54 ± 2.50	7.23 ± 2.83	1.92
	Food pyramid	1.22 ± 0.97	2.44 ± 1.24	2.21 *	0.89 ± 0.90	1.13 ± 1.18	0.82
	Food safety and package	3.11 ± 1.45	3.00 ± 1.32	0.11	1.54 ± 1.13	2.15 ± 1.28	1.28
Attitude	Importance awareness	4.03 ± 0.98	4.25 ± 0.83	1.28	3.94 ± 1.08	4.33 ± 0.83	1.85
	Self-efficacy	4.07 ± 0.49	4.11 ± 0.62	0.11	3.33 ± 0.77	4.00 ± 0.92	2.42 *
	Willingness to adjust	3.77 ± 1.01	4.48 ± 0.67	1.61	4.56 ± 0.55	4.56 ± 0.52	0.00
Behavior	Balanced intake of nutrients	4.00 ± 0.94	4.00 ± 0.75	0.27	3.61 ± 1.37	4.42 ± 0.79	1.61
	Food intake frequency	4.18 ± 1.03	4.29 ± 0.73	0.41	4.23 ± 0.85	4.79 ± 0.48	2.55 *
	Reading food labels	3.78 ± 0.83	4.11 ± 0.78	1.13	3.85 ± 1.21	4.77 ± 0.44	2.40 *

Note: * $p < 0.05$.

4. Discussion and Conclusions

4.1. Discussion

4.1.1. Effects of the Board Game on Students' Knowledge, Attitude, and Behaviors

Nutrition knowledge that teenagers need to master is relatively simple compared to other science subjects. Many nutrition education programs using game-based teaching to improve students' knowledge to varying degrees. Knowledge improvement is also related to the difficulty. In the Giocampus program [24], the research carried out a nutrition education program containing different topics with different difficulty levels in the third to fifth grades of a primary school and found there was no significant change of scores among senior students on many types of questions. That is mainly because senior questionnaires contained difficult questions (e.g., about carbohydrates and fiber). In this study, after a 6-week intervention, students' total knowledge scores had significantly improved, but when focusing on certain knowledge points, there were no significant changes in food safety and package. That is mainly because the different kinds of knowledge points are not evenly distributed, such as food poisoning and GI value, which are only present in examinations with a high level of difficulty. Students had fewer opportunities to use this knowledge, thus they saw little improvement. In addition, students are more apt to get higher grades in qualitative judgment questions (e.g., what nutrients are rich in certain food? What is nutrient deficiency?) and get lower grades in quantitative comparison questions (e.g., comparing the food calories), mainly because qualitative knowledge is easy to perceive due to the promotion mechanism. Although quantitative thinking is involved in the game, students are more easily impressed by foods with large energy differences.

In nutrition education, it is more important to improve students' dietary attitude and behaviors rather than just delivering knowledge. Therefore, it is necessary to motivate students' intrinsic motivation, promote their transformation from attitude to behavior, and guarantee the program's duration. Previous studies have found that the short duration of educational programs is a major obstacle to teaching effectiveness [25]. The game-based learning method can give students a better sense of immersion and can be used as a long-term teaching activity. In this study, significant improvements of attitude and behaviors were only found in the formal study, but not in pre-study, which also prove that lengthening the duration of the program can help to promote students' transformation of attitude and behaviors. In addition, teachers' guidance before each activity was added to deepen students' cognition of dietary influence in the formal study. Additionally, the number of people in each group decreased from five to three, which meant the participation time of each player increased. That corresponds to some previous studies that showed reducing the number of study groups helped to enhance students' participation and made them more likely to be driven by positive teammates [26].

In general, students had significant improvement in some dimensions of behaviors. The main changes were that the intake frequency of breakfast and eggs increased, whereas

the intake frequency of fast food and sugary beverages declined. The intake frequency of vegetables and fruit was relatively high, so there was no significant change between pre- and post-test. In the interview, students mentioned they usually had lunch and dinner at the school canteen, so the intake of vegetables and fruit could be guaranteed without much change, which was consistent with Roszanadia's findings [27].

It can be concluded that students' behavior transformation concentrated on some types that are easy to adjust. For example, as reading food labels is easy, students' scores significantly increased in the post-test. However, they did not have significant change in the balanced intake of nutrients, because this dimension was more difficult, requiring students to have a more comprehensive understanding of their dietary structure and food characteristics. It still needs more time and motivation for further promotion, such as the enriching incentive mechanism of the game.

Some studies also found the influence of game-based teaching may continue to play a role in students' later learning and life, showing a significant improvement in the delayed test [25]. In the delay test of this study, students' scores of willingness to adjust had significant enhancement compared to that in the pre-test, because students may put ideas from the game into the reality and deepen their cognition, which was also noted in the interview. Scores of other dimensions of the delay test basically had no significant enhancement, but they also showed a long-standing effect.

4.1.2. Differences in the Effects of the Board Game on Students with Different Gender and BMI

Some studies found that factors such as gender, economic level, and physical quality would influence the teaching effect of the educational game. For example, Ogunsile and Ogundele [28] found girls got higher KAP scores than boys in an educational board game. There was a similar finding in this study—that girls got higher scores in both the pre- and post-test—though without significance. In the terms of attitude and behaviors, boys and girls had different changes. For instance, only girls had significant improvement in the willingness to adjust and food intake frequency. As junior school students have entered puberty, girls develop their secondary sexual characteristics earlier than boys and they may pay more attention to their appearance. They had learned that nutrition intake had much to do with body shape, so girls may be more easily influenced by the nutrition knowledge and therefore adjust their behaviors.

Teaching effects also varied on students with different BMI ranges. Underweight and overweight students had significant increasing scores in self-efficacy and food intake frequency, whereas students with normal BMI value had no significant change. One reason may be that students with abnormal BMI got lower scores in the pre-test, so they had larger room for improvement. Another reason may be that the guidance progress emphasized the relationship between food intake and energy transformation and the adverse consequence of fat accumulation in the game, which were more likely to call the attention of students with abnormal BMI values. Jennings [29] also found overweight students had stronger willingness to adjust their dietary behaviors, although they did not command good nutrition knowledge in a nutrition summer camp.

4.2. Conclusions

The board game is designed within the domain of chemistry, particularly nutrition. By incorporating game elements into crucial concepts of nutrition, the students are encouraged to understand the concepts and elements and explore the relationship connected within. The knowledge, awareness, and self-efficacy of the students have been significantly enhanced, although the changes happened unevenly for boys and girls and for students of different BMI. It is still not easy to translate the knowledge to dietary attitude and behaviors.

As nutritional knowledge might be deficient for children and adolescents, board games can help to impart the knowledge in an entertaining format, which provides an alternative to chemistry classes. There is limited evidence for the effectiveness of board games for

nutritional education. Further research is warranted to evaluate the long-term effectiveness of board games on nutritional knowledge and dietary behavior.

5. Limitations and Prospects

Due to the small sample size of this study, the result may be not representative. Additionally, the intervention was only carried out for 6 weeks, but it was still short for transformation of attitude and behaviors.

Through the evaluation of teachers and students, this board game still has much space to develop:

- Developing assisting app: helping students to do calculations and giving some tips for motivation.
- Strengthening logic and knowledge progressiveness of knowledge points: The distribution of knowledge points was designed to satisfy game's scenarios, making it scattered in the game and not from a logical system. Without guidance and explanation of the teacher, it will be difficult for students to establish a complete knowledge system on their own only by game instruction. It would be favorable to adjust game tasks and make students master knowledge step by step.
- Adding game scenarios: some students advised designing more character cards with different food intake goals for them to draw out before the game. Therefore, they can get more enjoyment and establish the relationship between knowledge and reality.

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