Pupil's Fraction Learning Based on Board Game Playing

Primary school pupils have good mathematics learning achievements but lack interest and attitude towards mathematics learning in Taiwan. Therefore, it is necessary and feasible to study how to use game-based learning in mathematics. In this research, the board games are adopted and designed by the team members then be integrated into the learning of mathematics fractions. The pre-test and post-test are designed to analyze the effectiveness of pupils using board games for learning and the formation of fraction conceptions, supplemented by interviews to understand pupils' interest and attitudes changes in learning. Research has found that pupils who only use board games for learning can recognize and read unit fractions, which can achieve the expected learning goals and enhance pupils' interest and attitude towards mathematics learning. Finally, the limitations of this research study and the directions for future research are also proposed.

Keywords: *board game, fraction learning, game-based learning, teaching aids*

Introduction

In order to implement the concepts and goals of the 12-year National Basic Education Curriculum in Taiwan, the curriculum takes "core literacy" as the main axis of its development to facilitate the continuity of various educational stages and the integration of various disciplines. Among them, "core literacy" refers to the knowledge, ability, and attitude that a person should possess in order to adapt to the current life and face the challenges of the future. Therefore, "core literacy" emphasizes that learning should not be limited to subject knowledge and skills, but should focus on the combination of learning and life, and demonstrate the learner's whole-person development through practice. (Ministry of Education, 2018)

According to the results in TIMSS (Trends in International Mathematics and Science Study), the fourth graders' achievements of mathematics learning in Taiwan are ranked among the best, but their interests and attitudes towards

mathematics are far lower than the average of participant countries (TIMSS 2011, 2015, 2019). Research shows that fourth-grade pupils of primary schools in Taiwan tend to dislike and have no confidence in mathematics, and believe that mathematics is a non-practical subject but high achievements in mathematics. Comparing with the standards proposed in the syllabus, it is clear that in mathematics, pupils are not equipped with the core literacy they should have. Therefore, it's worth studying that how to enhance pupils' motivation and interests in mathematics learning in the future.

Game-based learning is a learning model that has emerged in recent years. Any learning method that uses tools or activities to enhance learners' motivation and interest can be classified as a part of game-based learning. Although it has been mostly referred to as digital learning in recent years, it is not a learning method that focuses on exponential games (Plass, Homer, & Kinzer, 2015). Broadly speaking, fun-oriented learning refers to designing an interactive process that can achieve a balance between the needs of subject knowledge and the needs of gameplay (Plass, Perlin, & Nordlinger, 2010). Hou (2016) also believes that learning from playing can bring out student’s interests well in learning.

Board games are also called unplugged games. It covers games that do not rely on electronic devices and electronic products, such as card games, board games, dice games, and multiplayer face-to-face games. A general term for games played in the same space. Board games are not only fun to play, so that pupils can play with interest, but the depth and diversity of board games can also enrich pupils' life experience, depending on how teachers use them. According to Shulman (1986) research, in order to achieve effective teaching performance, teachers need to have three types of knowledge, namely content knowledge (CK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK), is to understand how to effectively teach the content of a certain subject. Related research has found that when teachers have a wealth of PCK, it is indeed helpful for pupils' learning. Therefore, if teachers want to improve students' interest in learning and learning effectiveness in order to teach mathematics well, and refer to the use of board games to integrate mathematics teaching for pupils in primary school, will there be any changes in teachers' PCK? And what are the changes? Will it help teachers' professional growth in mathematics to enhance the effectiveness of pupils' mathematics learning, and cultivate the core mathematics nurturing of pupils at the same

time? These are worth researching.

" Education is nothing but a concern for love and role model." The learning effectiveness of pupils is closely related to the teaching of teachers. Researchers are very interested in forming effective teaching in the field of mathematics in primary schools. Studies have shown that entertaining mathematics learning has a positive effect on pupils' learning effectiveness or learning literacy. Therefore, if mathematics board games are incorporated into primary school mathematics teaching, will teachers' PCK be different from applying the teaching aids? How to develop mathematics literacy-oriented teaching with expert teachers? It is really exciting. Therefore, the research intends to answer the following unanswered questions first:

(1) Can students learn the concept of fractions through board games?
(2) What is the effectiveness of pupils' learning through board games of fractions?

Literature Review

Game-Based Learning and Board-Games

(1) Game-Based Learning

Game-based learning is usually defined as a model of learning by using computer games as a medium. What is game-based learning in education? 'Game-based learning' broadly refers to the use of video games to support teaching and learning. Although it is a relatively established notion, it is hard to define precisely (Perrotta et al., 2013). Therefore, because of the evident motivational qualities of games, educators and trainers alike seek to use them for instruction.

It is argued that games could change education because it makes it possible to learn on a massive scale by doing things that people do in the world outside of school: "They make it possible for students to learn to think in innovative and creative ways just as innovators in the real world learn to think creatively…but they can do this only of we first understand how computers change what it means to be educated in the first place" (Shaffer, 2006, p. 23).

Mathematics learning is difficult and unconfident for pupils in Taiwan, so that to seek interesting and meaningful teaching aids for mathematics learning is quite urgent and necessary. Sharma (2012) considered toys and games are synonymous with play, pleasure, and relaxation. Almost everyone likes to play and, in one form or other, this continues throughout one's life. Play is not just a filling in of an empty period or a relaxation or leisure activity, it is also an important learning experience- an essential ingredient for growth and development for children and adults alike. Therefore, if games and mathematics learning can be combined, it should be quite effective in cultivating students' knowledge and skills. Although, researchers (Games & Squire, 2011) and game designers (Prensky, 2011) indicate that games specifically designed for educational purposes are not as much fun to play compared to those designed only for fun. Educational games are certainly not as widely distributed, or as successful financially as those developed for amusement (Tobias et al., 2014), but using games (not just digital games) to learn mathematics is still a topic worth researching.

(2) Board Games and Educational Expecting

In recent years, board games have gradually emerged in leisure activities and have gradually attracted public attention in Taiwan. Board game (or named 'tabletop game', 'table game') generally refers to that there is no need to plugin, as long as it is any game played on a flat surface, it is considered a board game, so it is also called "unplugged game", including card games (also including trading card games), board games, tile-based games, etc., as well as other general names for games played on the table or any multiplayer face-to-face plane. Broadly speaking, chess, poker, mahjong, etc. are also board games. Board games also generally refer to games that do not rely on electronic devices and electronic products, and usually do not require large-scale actions.

Among the many games, board games, which require less time than others, have become the choice of activities when gathering together. Compared with other types of games (such as video games and group health games), board games have barriers low to entry, convenience high, and the concept of group interaction, so it is suitable as a medium for interpersonal interaction. Michael Mindes, the founder of'Tasty Minstrel Games' company, mentioned that board games can provide new ideas for learning, interpersonal interaction and life

connections. When children want to win and have enthusiasm and motivation to learn, they will get the greatest pleasure. When playing board games, participants need to interact with each other and require a variety of abilities, such as concentration, expression, reaction, judgment, memory, empathy, logic and reasoning skills. Feel and experience the interaction and feelings of different situations through activities. Learning in games may include the use of games designed for learning purposes, as well as games that were not originally built for the education market. Many researchers have found their learning value.

Figure 1. Model of game-based learning

Let us consider, based on the Model of game-based learning Figure 1, how and when learning occurs when learners interact e.g. play a game, contrast with board game, there are six characteristics (Wu, 2011):

Personal actual participation: stresses the interaction between people.

Safety: Compared with group active games or sports, it will not be hurt.

Flexible: According to the different attributes and needs of players, choose suitable game scenes.

Easy to get staredt: The entry barriers of the game are low, and you can choose a suitable game according to the player's level.

Convenience: It is less affected by the venue, weather, and equipment, as long as there is a flat surface and the board game starts.

Encourage interaction: Whether it is a competitive game or a cooperative game, it is necessary to communicate and negotiate with each other through language or expressions in order to influence or persuade the other party to propose ideas or strategies.

In the course of many years of teaching, researchers have devoted themselves to combining various games with learning. Through long-term observation, we have found that learners of any age group are more capable of focusing on game-like interaction methods. And interest, the main reason is that all individuals can adjust the learning rhythm with their own adaptability during the game, and because the game has many cyclic characteristics, all individuals can receive the effect of repeated verification without falling into boring. Pupils can set goals according to their own abilities. For example, those who are quicker in learning response can further challenge the answering speed after reaching a higher rate of correct answering; on the contrary, those who need more time for learning response can also gradually improve step by step. Accumulate the number of correct answers, even if learners have differences in learning abilities, they can cooperate and be compatible, advance together, compete, and help each other, and further match the rigorous rule design, so that learners can form a co-prosperity and coexistence. The relationship between peers, to give play to the power of mutual help and mutual learning among peers, to enhance the sense of honor gained by those who are superior in learning, and to strengthen the willingness to learn again for those who are lagging behind in learning. The effect is indeed better than that of a single teaching and teaching mode.

(3) Designing Playful Learning by Using Educational Board Game

Board game according to Scorviano (2010) in Game Board History and Game Psychology, the board game is a type of game where tools or parts of a game are placed, moved, or moved on a marked or divided surface according to a set of rules. The game may be based on a pure strategy, opportunity, or mixture of both and usually has a goal to be achieved. The media board game games need to be developed because there are currently many games that only contain cognitive aspects such as play stations and online games without regard to affective and psychomotor aspects which can cause students to have high individualism (Erlitasari & Dewi, 2016). In addition board games can be used as a channel for information and help in the learning process. That agreed with Gagne (Sadiman et al., 1990) states that the media are various types of components in the student environment that can stimulate learning. The use of shapes and colors that match with the characteristics of students and the

challenges that exist in this board game, students will be more interested in understanding learning materials because they can learn while playing.

Some of the studies, including Erlitasari and Dewi (2016), have developed integer line board media games in grade IV elementary school. Furthermore, Fathurrohman (2016) has developed a labyrinth game board for calculating operating material for elementary school. Ningrum and Mariono (2016) have developed board game visual media in the material of Junior high school Algebra form, as well as Prasetyo (2018) which has developed the game of mathematical monopoly on the material of the straight line equations for class VIII junior high school. The results of the research concluded that the media created had a positive impact on students' interests and learning outcomes. Above on, Several studies have proven the positive impact of using board game media on student learning outcomes. The existence of the theory and results of the research, then as a form of follow-up efforts on existing problems, the researchers will develop board game learning.

Therefore, the board game that will be developed is expected to improve the teacher's insight into the method of playing board games, overcome students' boredom in learning, and foster interest in learning. In addition, the board games can also be used as learning tools that are developed based on aspects of validity, practicality, and effectiveness especially for learning mathematics in Algebra material, as well as a means of training questions for the student and can be used by other teachers who can improve Learning Innovation (Andini & Yunianta, 2018).

For mathematics learning, a meaningful learning task is necessary. Meaningful learning tasks have the following mathematical characteristics, according to Wittmann (2010):

(i) Elements (entities) are provided, which can be mathematically defined and which are in mathematical relations to each other.

(ii) The elements can be dealt with using mathematical rules.

(iii) The mathematical activity has an aim. It therefore always includes the examination of patterns and orders and problem-solving through the use of these structures.

(iv) The mathematical learning activities need to be a foundation for future learning processes.

In summary, combining teaching aids with mathematical game rules to create an educational board game for pupils to learn in the game is a topic worth researching.

Mathematical Fraction Concept Instruction

(1) Fraction Conceptual Development of Pupils

Piaget (1960) pointed out that the cognitive development of children is gradual. He used his theory of children's cognitive development and designed activities to study children's development of the concept of fractions, and found that the relationship between the part of perception and the whole and the subdivision of operation There is great difference between them. Piaget, Inhelder and Szeminska (1960) did a series of studies on the development process of the fraction concept of children aged 3 to 8. At the same time, they also found that children must have the following seven sub-concepts:

(i) There must be a whole that can be divided in order to have fraction thinking.
(ii) Fraction contains the limited number of each part, and each part must correspond to the recipient when assigning things.
(iii) In the sub-segmentation activity, all must be exhausted and there is no remainder.
(iv) There is a fixed relationship between the number of parts that the whole is cut into a number of cuts.
(v) The concept of fractions means that each part after division is equal.
(vi) When children manipulated part of the subdivided concept, they learned that the subdivided part is a part of the whole. At the same time, this subdivided part itself is also a subdivided whole.
(vii) Because the fraction comes from the whole, the whole is always the same.

Based on the aboves, the concept of fractions for students comes from the experience of dividing into equal parts. Therefore, through understanding after manipulating, it will be a learning process that is more suitable for the development of students.

(2) Curriculum Structure of Mathematics Fraction Concept in Taiwan

Fractions often have different usages and interpretations due to different situations. Many scholars have different views on the meaning of fraction. They analyze the cognitive significance of fractions in different problem situations and all advocate that fractions have multiple meanings, some instances are as follows (table 1):

Table 1. Different Views of Scholars of Fractions

Scholars	Proposal Year	Meaning of fraction
Kieren	1976	Propose seven interpretations of rational numbers: fractions, decimals, ratio, ordered pairs, quotient, measures, operator.
	1980	Simplify it into five interpretations: part-whole, ratio, quotient , measures, operator
	1988	Simplify to: ratio, quotient, measures, Multiplicative operators.
Behr, Lesh, Post & Silver	1983	Seven different meanings of fraction : fraction measures, ratio, rate, quotient, linear coordinate, decimals, operator..
Dickson, Brown & Gibson	1984	different meanings of fraction: 1.Sub-area of whole region. 2. A comparison between a subset of discrete objects and the whole set 3.A point in number line which line at intermediate point between two whole numbers. (4) The result of a division operation. (5)A way of comparing the sizes of two sets of the objects or two measurements.
Nesher	1985	There are five interpretations of fraction: part-whole, quotient, ratio, operator, probability.
Ohlsson	1988	Divide into four constructions and eleven meanings: 1. The quotient function: contains equal

	division(partitioning), including (extracting), shrinking (shrinking), Educing. 2. Rational number : including fractions and measurement(measures). 3. A binary vector: ratio, intensive quantities, proportion, average (rate). 4. Synthesis function.

It can be seen that the meanings of fraction are multiple although all the meanings of fraction are not included in the textbooks at the primary school stage in Taiwan. Shares of all, sub-sets of sets, fraction of equivalent value, fraction value is a point on a number/number line, the result of integer division, averages, ratios in proportions, the meanings of fraction in primary period summarized as in Table 2:

*Table 2***.** Different Meanings of Fraction and Learning Age in Taiwan

Concept of fraction	**Description**	**Grade (pupil's age)**
Equally divided	In specific situations, the activities of dividing and dividing equally are carried out, and the meaning of "even dividing" is used to describe the meaning of equal distribution.	Grade 2 (about 7 years old)
Part/All	In the "whole 1 (unit quantity)" problem scenario, after dividing a whole into equal parts, the relationship between the partial quantity and the whole quantity of the N sub-division units is expressed as a fraction.	Grade 2 (about 7 years old)
Addition and subtraction with fraction	In specific situations, initially understand the addition and subtraction of fractions, and solve the problem of comparison and addition and subtraction of fractions with different denominators.	Grade 3-5 (about 8-11 years old)
proper fraction, improper fraction, fraction with	Understand the interchange of proper fraction, improper fraction, fraction with integer, proficient between improper fraction	Grade 4 (about 9 years old)

integer	and fraction with integer.	
Equivalent fraction	In the existence of a whole, the equivalent fraction is used to indicate that the "part-whole" relative relationship of the two quantities does not change in the context of continuous or discrete quantities.	Grade 4 (about 9 years old)
The fraction is a number/a point on the number line	Extending the simple integer number line to the fractional number line, the meaning of the fraction is extended to a point on the number line. The fraction value of this point on the number line represents the relative relationship between this point and the origin and the unit length and the origin after the origin and unit length are determined.	Grade 4 (about 9 years old)
The result of integer division	When the division of two numbers cannot be divided by an integer, the result of the division is expressed as a fraction, for example, 3÷9=3/9	Grade 5 (about 10 years old)
Average (including rate)	Use fractions to express the result of comparing two measurement units with one of them as the benchmark. For example, rate is the result of comparing length and time.	Grade 6 (about 11 years old)
The ratio in the ratio / scale / ratio / comparison amount ÷ reference amount	When the result of comparing two sets or two measures, the representation of the scale and the ratio are expressed in p/q, the meaning of the fraction is the result of the comparison of the two quantities.	Grade 6 (about 11 years old)

In order to be transformed into teaching guidelines for teachers, the syllabus of mathematics is written into learning performance and learning content. Content about fraction is excerpted as in Table 3:

Table 3. Curriculum of Fraction in Primary School Grade 1-2 in Taiwan

Grade (age)	**Learning content code & describe**	**Learning performance code & describe**
Grade 1 (6)	None	n-I-6 Recognizes the unit

	N-2-9 Problem solving: split and split. Focus on operational activities. Divide preexperience. Understand the meaning and method of split packaging and equal splitting. Guide students to discover the connection between the problem and the multiplication mode in the problem-solving process.	fraction.
Grade 2 (7)	N-2-10 Recognition of unit fraction: Recognize that the single part is "a fraction" of the whole from the activities of equal distribution (such as paper origami). Know the communicative meaning of "half", "half of", and "quarter of" in everyday language. In an evenly divided grid graph, it can be illustrated that one grid is "a fraction" of the whole.	

This study is based on the fraction concept of grades 1-2 in Taiwan primary school stage as the learning objective. Therefore, only part of the required syllabus is listed. The learning goal of this stage is to communicate the meaning of fractions, that is, to understand the meaning of fractions and the naming of fractions, that is, to be able to write "1/4" and say "1/4" of the learning goals. In particular, the reading of fractions in English is to read the numerator first and then the denominator, but in Taiwan, the reading method is to read the denominator first and then the numerator. Students are expected to confirm all the cuts first, and then judge the number of parts. This part sometimes allows students to write wrong scores or wrong reading. This part will be explained later when there is a chance.

(3) Lack of Game-Based Fraction Learning and Board Game Designing

After collecting board games in Taiwan, they are related to the “Number”,

"Amount", and "Shape" mentioned in the mathematics curriculum. These board games are related to mathematical concepts. We call this type of board games as "Mathematics Board Games". There are many kinds of mathematics board games. Basically, the activities that determine the winner by counting scores, although required calculation experience to be carried out, but we excludes choices that only have this nature. The mathematics board games we referred to activities that can learn mathematical concepts during the game playing, or solving problem with mathematical concepts. Take the themes of number, amount, and shape to illustrate:

(1) Number- "COWABANGA": The situation is to go surfing with his own cow. The players need to control the height of the wave with the number poker card in their hands to avoid dangerous factors in the sea and avoid injury. This board game tests the player's ability to calculate the addition of integers. When the board game is set in the retreat phase, it tests the player's ability to calculate the subtraction of integers.

(2) Amount- "Noah's Ark": The game consists of actual, reduced animal models with different weights, and cards with animal photos. The player draws a card from the animal cards, and selects the correct animal from the animal pile according to the pattern and name on the card. Since animals are different in size and weight, pupils must maintain the balance of the Ark, so they must be carefully placed on Noah's Ark each time, and then the next pupil will draw cards to continue the game. The test is the feeling of weight.

(3) Shape- "Geistesblitz": This board game contains five small models of different colors and tools, as well as some pictures of playing cards. In each round, a player draws a card from the card pile and puts it on the table, because the shape and color shown in the card may not be the same as the actual tool. Only one option in each card will be the same as the actual tool, the player must grab the only same tool as fast as he/she can, the winner can get a point, and then continue to the next round. This board game tests the players' quick judgment on shape and color.

There are no board games about fractions. For example, "Splittissiuo" is a board game. The game uses round cards, which is marked with a pizza sliced in

eight equal parts. There are 0, 1/8, 2/8, 3/8, 4/8, 5/8, 6/8, 7/8, 8/8 cards, if the player can combine the two cards on the table into a whole pizza, then the player can get the card back and get the scores of the game; or you can find three cards and combine them into a merged relationship.

But for the fraction mathematics board games collected so far, students must have a basic concept of fractions before they can play the game. For example, in the rules of "Splittissiuo", how do students know which two round cards can be combined into a whole one? What about the complete drape? These mathematical concepts require experience and guidance, as well as prior experience in reading the information on the chart. Therefore, this type of game is suitable for mathematics exercises. If it is used in mathematics teaching, there will still be shortcomings.

Although it is not possible to collect all the board games for analysis and research, it is probably understandable why no board games related to the preliminary concept of fractions in this research can be found. Because the recognition of the fractions comes from the establishment of the relationship between the total amount and the part being cut, it is difficult to emphasize the whole amount and part of the amount from the game image if there is no cutting mark.

Therefore, this research attempts to enable pupils to observe the proportion of the partial amount to the overall amount from the previous experience of dividing and equalizing in the process of the game, try to describe these phenomena that are less than 1, and learn to express it in fractions.

Materials and Methods

Design the Board Game with Fraction Concept Guiding- Pull the Fraction Down

In order to create a situation where board games are used for learning, we refer to some board game rules and create a concept related to fractions based on the first grade (pupils' age about 7) -related learning content in the mathematics syllabus for elementary schools in Taiwan math board game.

The main learning performance of the second graders in the fraction unit is "Recognizes the unit fraction." Therefore, they must be able to "listen", "speak",

"read" and "write" for the unit fraction. Therefore, these should be integrated into the board game design process Elements to achieve the purpose of board game learning.

Teaching with Board-Game of Fraction

The learning of mathematics fractions should be meaningful and life-like and reduce the direct definition of learning to reduce the fear and pressure of pupils on math learning. Therefore, we look forward to using board games to integrate into the learning of pupils or the teaching of teachers and to minimize the situation of teaching directly in the form of mathematics.

We invited eight current primary school teachers into the teaching site to lead the pupils' board game activities. In addition to observing the learning effectiveness of elementary and elementary school children after using board games to learn, we also observed how teachers integrate board game activities into teaching. The teachers come from two different schools in Taichung, Taiwan. There are two teachers in School A (one is a 6th grade teacher, one is a 1st grade teacher), six are B school teachers (two are 1st grade teachers, one is a 2nd grade teacher, one teacher in grade 3, one teacher in grade 4, one teacher in charge of science teaching in grades 5 and 6)

Assessment for Board-Game Learning

In order to be used in classrooms, we hope that the design of this math board game can enhance students' interest in learning and have learning effects. Therefore, we hope to understand the effectiveness of students' learning through some tests and interviews. , And whether students' interest in learning has improved.

(1) Learning Effectiveness

We have made two tests, one as a pre-learning test to examine the students' previous experience; the other as a post-learning test to evaluate the effectiveness of the post-learning. The subjects of the test are from elementary school grades 1 to 6 (6 to 11 years old). The purpose is to test the children's ability to use digital symbols to represent images. Therefore, most of the test

questions in the test paper are represented by pictures, with fewer words; To reduce the trouble of students answering questions, the answers are mostly multiple-choice and filled-in questions, without narrative questions.

The pre-test is mainly to test the children's ability to use digital symbols to record image representations, such as the below figures.

Figure 2. '2.Which one represents " 6" ? Make a ✓on your answer.'

Figure 3. '5.Which one represents " 6 ÷ 2" ? Make a ✓on your answer.'

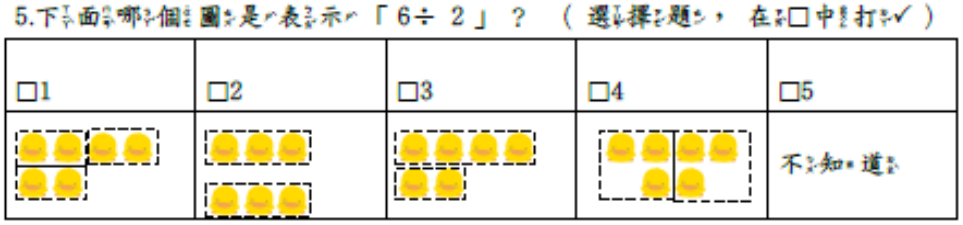


Figure 4. '6. Which one represents " $\frac{2}{4}$ " ? Make a ✓on your answer.'

The pre-test is mainly to test the pupils' ability to record image representations with numerical symbols, such as in the figure2, '2.Which one represents"6"?' Make a ✓on your answer. And in the figure 3, '5.Which one

represents "6 ÷ 2"? Make a ✓on your answer.' is used to evaluate whether students can use numbers and calculations to represent the meaning of the images. '6. Which one represents "2/4"?' is to assess whether students have the ability to represent images with fractions, as shown in figure 4.

In the test after board game learning, we want to know whether students can use fractions to represent graphics, such as '1. Write a number so that the result has the same meaning as the figure, and write the spell of the fraction.' The numerator of the answer is both 1. Will the children's observation of the image misunderstand the number of divisions instead of the number of parts after division? '2. Sort the codename with the amount of each figure.' is to test whether the children's intuitive comparison of the amount is correct. '3. Sort the fraction below: 1/2, 1/4, 3/8 without figure.' is to observe whether students have a correct understanding of the amount expressed by the fraction. These are examples of test questions, and each question design has indicators to be observed.

Figure 5. Post-test '1. Write a number so that the result has the same meaning as the figure, and write the spell of the fraction.'

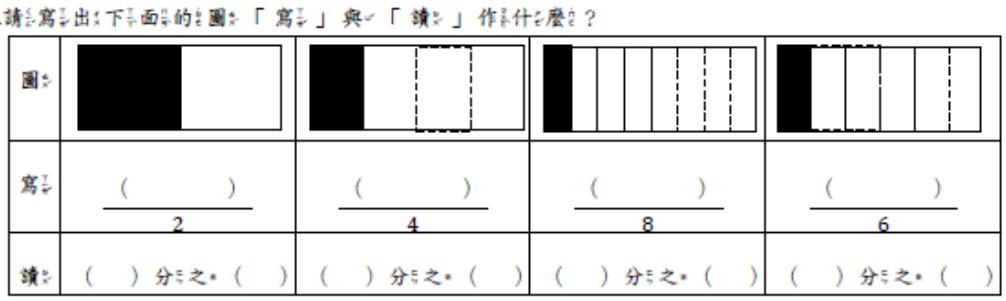


Figure 6. Post-test '2.Sort the codename with the amount of each figure.'

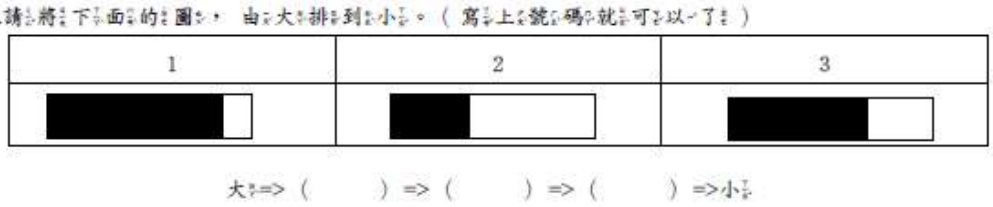
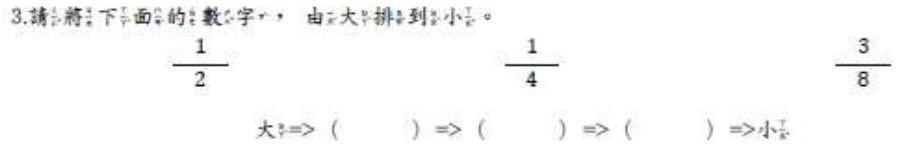


Figure 7. Post-test '3. Sort the fraction below: 1/2, 1/4, 3/8 without figures.'



(2) Learning Interest

There is only one question on the pre-test and post-test to investigate students' interest in mathematics and board games. In the pre-test, students are asked to give mathematics an "interest level" of 10 points to represent their favorites, and 0 points to dislike them very much; in the post-tests , It is to let students have an "interest score" for math board games. A score of 10 means that they like it very much, and a score of 0 means that they hate it. We then conducted interviews with several school children based on the pre- and post-tested learning effectiveness and interest scores. The distribution of the number of interviews is as follows:

Table 4. Distribution of Studenst Interviews

	High achievement	Low achievement
High interest	2	2
Low interest	2	2

The sample of students in our study comes from two different schools in Taichung, Taiwan. The sample of the number of students in each school and each grade is shown in the table below. Among them, the fourth grade children cannot cooperate with the implementation of the time, so this study did not receive any information. I hope There is a chance to add more in the future.

Table 5. Pupil Sample Distribution

School\Grade	**1**	**2**	**3**	**4**	**5**	**6**
A	17	-	-	-	-	21
B	18	15	17	-	15	11
Total	35	15	17	-	15	32

Results and Discussion

”Pull the Fractions Down”-The Board Game of Fraction Design.

(1) Observation fractions: how to describe the size between 1 and 0? We have designed a "fraction ruler" appliance. Before pupils know how to read fractions, they can only see the green area on the card. At first, there is no way to describe it, but when they put the card into the fraction ruler, they can observe from the scale on the top, it is full a card is 1, but it is also divided into eight equal parts by these scales. When a card less than 1 is put in, you can see that there are six cells in the eight cells that are colored, with "? / 8" on the back. "8" implies that there is an eight-division scale in front of it, and " ? " implies that what the pupils are allowed to observe is how much the color occupies. Therefore, what is measured with this "fractions ruler" is to observe the 1 in eight equal parts; in addition, there are also designs of four equal parts and two equal parts.

Figure 8. Fraction Ruler Front, Back and With the Color Card

(2) Fractions naming: In order to let pupils practice the naming of fractions, we created a situation where pupils participating in board games can act as magicians. In this game world, they can use spells to win, and the spells are what the cards represent fraction reading. Therefore, in order to say the correct spell, the pupils must first distinguish the amount of the card and tell the true reading of the card in the eighth, fourth, and second scale to win the game.

(3) Design and learning: The goal of learning is to cultivate pupils' ability to "listen", "speak" and "read" in fractions. Therefore, these learning goals are integrated into the design of the rules of the game. In "Pull the Fractions Down", each student has 5 fraction rulers of eight-division scale, 1 fraction ruler of four-division scale, and 1 fraction ruler of two-division scale. There are

three types of fraction cards: green, blue, and black, each Color cards have 0/8, 1/8, 2/8, 3/8, 4/8, 5/8, 6/8, 7/8, 8/8, so there are 10 cards in each of the three colors For fractions cards, pupils can choose five of the blue, green or mixed cards and put them in their own fractions rulers. The cards are facing and placed from left to right according to their amount. Therefore, only they know the correct spell (fraction) of this card. (Reading), these fractions are like a wall to protect yourself, the winner of the board game is the one who did not fall at the end. If you want to push down the fractions walls of other players, you have to speak the fractions walls of other players. If your fractions wall is listened to, the fractions wall will be pushed down. We expect students to learn and practice fractions in these activities.

Teaching

(1) In the past, when teachers in Taiwan taught mathematics, they emphasized the definition of mathematical symbols. For example, "a/b is meant that the ‘a’ parts of 1 divided into ‘b’ parts". Students often ignore the "parts be divided into" when practicing reading. The habit of observing and reading out the part of the quantity first, so we expect that in the board game activities, we expect pupils to observe the equal ruler to cut the card into 8 equal parts, and then observe how many equal parts the color occupies. Speak out the denominator first, then the numerator, and finally you can say the correct fraction. But sometimes teachers still use direct teaching methods to make the game go smoothly, for example:

Student G1: Teacher, I don't know what the spell of this card is?
Teacher T3: Look, this card occupies three of the eight, so its spell is three-eighths.

We expect teachers to guide the recognition of fractions in a guiding way. Therefore, we hope that when the children cannot tell the correct fractions during the board game, the teachers will first guide the pupils to understand the scales they use and confirm the denominator. Then, look at the numerator, that is, the number of squares that the color occupies, and combine the denominator and numerator to form the correct fraction as a spell, extending from the correct spell rules to the correct fraction reading.

(2) The rule design of the board game is to sort the cards by size before performing activities. Therefore, students can guess the correct card spells by this rule, for example, between three-eighths and five-eighths cards, except Outside of the special rules card, it should be four-eighths. Let the children experience the relationship between the actual size sorting and the score sorting. When comparing with the denominator score, the larger the numerator, the larger the score. But when the teacher wants to assist the children, he directly brings the relationship between the scores into the game guide, for example:

> *Teacher T4: Dear, what's the middle between 3 and 5? So how much is between three-eighths and five-eighths? You are really good, and you will know what spell to use to attack this card next time.*

Although the teacher's guidance is quite fast, it ignores the guesswork of the pupils. The number of integer points is indeed the ordinal number of 3, 4, 5..., but it is not helpful in establishing the sense of the quantity of the score. For example, if when he is using a four-equivalent ruler, when a four-eighths card is put into the four-element ruler, the fractions that will appear should be two-quarters. At this time, the pupils follow the teacher’s Guiding, answering four-quarters, which is not surprising. Therefore, we expect the teacher to guide the students to guess the amount of change before interpreting the fractions. For example: "Boys and Girls, this eight grid is full of three grids, this eight grid is full of five grids, which card will be between the situation? There are four squares in the eight squares? Two squares in the four squares? So what is the fraction spell of this card?" Let the pupils experience the inference of the quantity and the reading of numbers at the same time.

(3) In the process of preparing lessons, the teacher believes that it does not take too much time to learn the unit fractions that numerator is 1, because the denominator can be confirmed by cutting the items into several equal parts, and the numerator can be confirmed by taking out several equal parts. The points experience goes to the points of the denominator and numerator, and it does not take much time to learn. Since the education of primary schools in Taiwan is a staged education, the six grades of primary schools are divided into three stages. Each stage will be reclassified and teachers will be reassigned to teach mathematics. The advantage is that students can adapt to different situations. For group opportunities, you can also try different learning methods and

learning environments, but the mathematics curriculum is continuous, and the conclusions of learning will not vary from person to person. Therefore, if the learning fractions is an integer for the learning fractions, then the pupils will learn the concept reached is not a partial quantity of the whole quantity, but an explanation of the proportional relationship between the large whole and the small whole, and the pupils do not know what that means. We emphasize the correct reading of practice fractions, which is a conventional way, so we have integrated into the spells of the magic world. After all, if the spells are misspelt, their magic will not be able to achieve their wishes.

Learning

(1) In the learning achievement part of the score

In the pre-test, we designed some questions to examine some of the students' pre-learning experience, such as knowing the fractions, counting numbers, knowing the signs of addition, knowing the signs of multiplication, knowing the signs of division, knowing the signs of fractions, etc., corresponding to each grade performance, expressed in terms of correct answer rate (number of correct answer samples/number of subjects), and the results are shown in the following table.

Table 6. Results of Pre-test

Item	N	Heard	Characterization of				
Sch-Gra		Fractions	Counting	Addition	Multiple	Division	Fraction
A-1	17	76.5%	94.1%	82.4%	5.9%	35.3%	11.8
B-1	21	77.8%	88.9%	100%	11.1%	27.8%	33.3%
B-2	18	86.7%	100%	93.3%	40.0%	26.7%	33.3%
B-3	15	94.1%	100%	94.1%	41.2%	76.5%	47.1%
B-5	17	100%	100%	73.3%	60.0%	93.3%	66.7%
A-6	15	90.5%	95.2%	71.4%	38.1%	76.2%	52.4%
B-6	11	100%	100%	100%	45.5%	72.7%	63.6%

In table 6, we can see that the first grade (A-1, B-1) and second grade (B-2) pupils are not very familiar with the representation of multiplication and division, which is in line with the level of students at this stage; Have you ever

heard of fractions? There is a clear difference from knowing the representations of fractions. This also shows that students know the fractions but don't know the meaning of the fractions. In the third to sixth grades (B-3, B-5, A-6, B-6) students should have learned fractions according to their school age, but in the representation of fractions, there is no obvious high achievement. This phenomenon may come from the experience of pupils learning fractions and tests the characterization is different.

In the post-test, we design some questions to detect how children write fractions, recognize reading denominators, recognize reading numerators, compare quantities, represent fractions, reduce equivalence, and expand equivalence after board games. The performance is expressed in terms of the correct rate (number of correct answer samples/number of subjects sampled), and the results are as follows:

Table 7. Results of Post-test

Item Sch-Gra	N	Fraction Writing	Denomi -nator	Numera -tor	Amount Compar -ing	Fractions			
						Compar -ing	Represe -ntation	Reduce	Expand
A-1	17	27.9%	47.1%	14.7%	82.4%	3.9%	76.5%	0%	14.7%
B-1	21	16.7%	84.7%	19.4%	66.7%	0%	85.2%	0%	30.6%
B-2	18	31.7%	66.7%	21.7%	100%	0%	93.3%	0%	6.7%
B-3	15	72.1%	86.8%	72.1%	88.2%	11.7%	98.0%	29.3%	50.0%
B-5	17	98.3%	100%	98.3%	100%	84.4%	100%	86.7%	86.7%
A-6	15	100%	95.2%	95.2%	95.2%	76.2%	100%	100%	100%
B-6	11	90.9%	100%	91.0%	90.1%	48.5%	97.0%	81.8%	81.8%

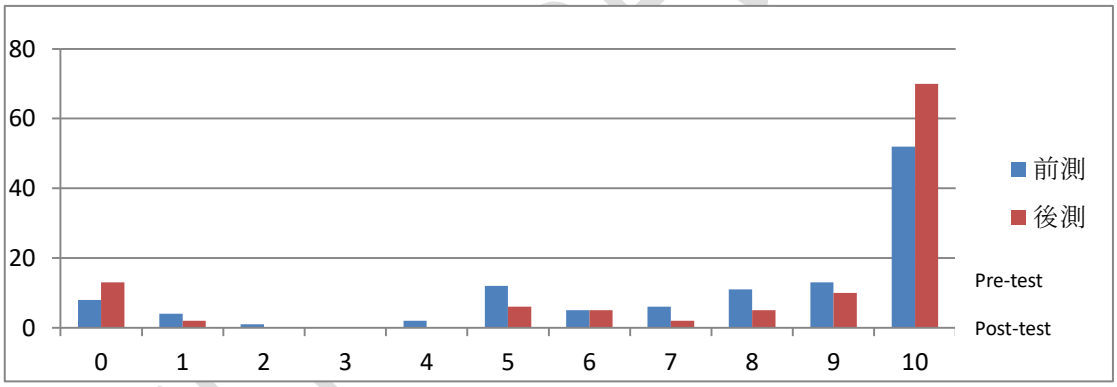
In table 7, it is worth noting that the first grade (A-1, B-1) and second grade (B-2) pupils can use fractions to express the amount of what they see. There is no obvious problem with the intuitive comparison of the pupil's presence, but if the comparison is based on fractions alone, the results have not been seen. In addition, when fractions interpreting and reading, the accuracy of the denominator is higher than that of the numerator. It can be guessed that the pupils have already observed how many equal parts of the whole quantity are, but further guidance is needed in the interpretation of the numerator. What is in line with expectations is that pupils have not yet had a clear learning effect on fractions writing . This involves the recording of fractions and needs to be

strengthened after being integrated into the mathematics curriculum. In the detection of equivalent fractions, the expanded fractions have begun to be interpreted by students, but the reduction of fractions is more difficult for pupils.

(2) In the learning interest part of the fractions

We interviewed the pupils about their interest in mathematics in the pre- and post-test respectively. It means that they are very interested, and a fractions of zero means that they are very annoying. For the statistical results, we use histograms to represent the results of the before and after tests, as shown in the figure as follows:

Figure 9. Interest of athematics(fractions) board game



We can find that the number of students who are very interested in mathematics learning through board games has increased significantly, while the number of people in the middle distribution has decreased. Although this is only a simple statistical analysis method, it can be seen that the way of learning mathematics through games can trigger the learning motivation of pupils. Even though they still know, the content of learning is the concept of mathematics. We interviewed several pupils from high achievement and high interest, high achievement and low interest, low achievement and high interest, low achievement and low interest. We found that regardless of whether the spupils have achieved high or low level of achievement, they are still playing games. Highly interested.

For high-achieving pupils, most of them can share ways to win, such as:

StG101: I guess. Because it is from small to large, if I already know one of the cards, I can guess that the two sides of this card will be plus or minus one, just like next to five-eighths, one It may be six-eighths, and the other side may be four-eighths. I usually guess right. This is the method I found myself, and I am very happy.

StG601: The order of the cards is regular, the colors are also regular, and there is only one card. I can see my own cards, so I know their cards must not have these five cards. If you add some reminder cards, I can guess what their card is. After playing it twice, I can win every time. I think I have found a way to win the game.

For pupils with low learning achievement, they provide more intuition and less thinking, but they still have the motivation to win:

StG201: I don't know what card they have, so I lock a card that I don't have. When it's my turn, I will guess everyone and I will always guess right. If others have guessed, I will remember, don't try to guess the same card or the same fraction again, it will be more accurate.

StG301: If I have any card in my hand, I think I will win better. Because other people's cards must be arranged in order, I can specifically find the same color to attack until all the fractions of that color are found. Although you can't win every time, at least it's not the first to get out.

Among the high-achieving and low-interest pupils, the special thing is that these pupils liked mathematics at first, but in the post-test they said they didn't like this board game, and they were all pupils who had already studied fractions and didn't like this. The reason for board games comes from not being good at games, even though they already know the rules well:

StG602: I don't like playing this math board game. This is too simple. They always guessed my card, and they only attacked my card, so that my card was pushed down quickly, and because it was pushed down, the other cards were easier to guess out. In addition, unfortunately, I have not been able to draw any cards, so it is easier to be guessed in the

order, and I can only be in a daze after being out. I don't like that there is nothing to do in math class.

StG501: Others said that my achievement in math is very good. This is a math game, so they are very afraid that I will win, so they all want to knock down my card first. Sometimes I was out of luck, and I got consecutive cards, and my cards were knocked down before the round was finished. In fact, this board game has nothing to do with math scores, because I don't think it needs calculations, so I can't perform well.

Among the low-achievement and low-interest students, the performance is quite similar to the high-achievement and low-interest students:

StG201: They all guess my card first, they only attack my card, it's not fun.

StG102: I will forget the card I guessed before, or I accidentally tell my own card, and then I lose. If there is a chance to play, I will pay more attention.

In the surveys and interviews of school children's interests, it can be found that pupils are willing to continue to learn in board game activities. Although their learning achievements have not been significantly improved, if they can maintain their learning motivation, let them continue to practice, Continue to accept the teacher's guidance, perhaps more time, the learning effect can be more easily observed.

Conclusions

1. It is feasible to integrate board games into math teaching

Game-Based learning can improve the learning motivation of pupils. Board games are unplugged games, which can be applied properly and can be effective when pupils are learning. Take this research as an example. Although the mathematics board game designed by the researcher is used, the initial purpose of the design is to guide the pupils to recognize the unit fractions. During the game, the pupils can be heard saying "three-eighths" and " fractions such as one-quarter" and "two-half" can indeed provide students with the

opportunity to speak the score. In the rules of the game, children need to hear the fraction spell to recognize whether their card is guessed by the other party, and recognize it. Performance of the ability to read fractions. Furthermore, from the results of the pre-and post-test, it can be found that the representation of the fractions before and after the pupils' board game activities has begun to change, and there is a growing trend. Although the effect needs further analysis to confirm, it can indeed be seen from the game process. It is found that the use of this set of board games for pupils can achieve the expected learning goals and maintain the learning motivation of the pupils. Therefore, the researchers proposed that the integration of board games into mathematics teaching does help the effectiveness of mathematics learning for pupils.

But it needs to be added that the elements used in board games are relatively simple. For the development of mathematics for pupils, the ability to "infer" has not yet been provided. The fractions can only be referred to as eighth, four and two. Equal division, for other denominator scores, the teacher's guidance is needed. Therefore, it is only recommended that board games can be integrated into mathematics teaching and learning, and cannot be replaced.

2. The design of rules makes board games more than just teaching aids to assist teaching and learning

The board game design of this research aims to allow pupils to measure the card with an equal scale after the operation. It is an example of part accounting for all. Therefore, assisting pupils to interpret fractions is provided by the design of the equal scale. Function, and to let pupils have experience and feelings about the quantity represented by the fractions, is to provide a context for the pupils to operate, such as the sorting of the quantity and the sorting of the scores. In addition, it is necessary to say the correct fraction to achieve the effect of attack. Therefore, in addition to the correct fraction word, in order to win the game, the strategy that the pupils must develop will be based on the known amount of cards. Estimate the number of unknown cards, and then guess what the possible fractions the cards represent. Feel the increase and decrease of quantity, can express it with correct numbers, and set the rules to guide students to form winning problem-solving strategies, and achieve the establishment of the teacher's expectation of the sense of number, which is more a combination of the sense of quantity and number.

However, it should be noted that because school children are the main body of the game and the main body of learning, once the strategies formed are provided by teachers rather than constructed by school children, the effectiveness of learning will be affected and it can also be expected. Therefore, entertaining learning comes from the devotion to games. Teachers should not replace the children in the game to win, but guide the pupils to discuss the game, discover the rules of the game, and then achieve the achievement of winning.

3. The fun-oriented learning comes from the fun-oriented teaching design

Game-based learning needs to be designed in order not to deviate from the purpose of education. These are the key points of teachers' teaching. However, if teachers talk about too many definitions in the process of games, pupils' learning will just conclude some words and behaviors training by imitation without thinking logically that mathematics study pays attention to, then this kind of mathematics teaching and learning cannot be said to be interesting, because we would not think that memorizing the provisions of the law is an entertaining learning. Therefore, in order to make teaching entertaining, we need to design close to the learning objectives, discuss how to incorporate the performance of learning into the rules of the game, and show the effectiveness of learning during the game. These are things that need time to design, and It takes time to prove it.

In this study, only part of the time was used for board game activities. Most of the teacher's teaching was only guided by rules, and there was no opportunity for extended discussions on fractions. Therefore, the effectiveness of learning needs to be strengthened, such as fractions. The writing method, as well as different denominators but equivalent score judgments, all have to be guided by teachers using time. In the process of board games, it can be seen that pupils can maintain a certain learning motivation, and how teachers can continue their motivation to deepen and broaden learning, and continue to add some gamification elements. Perhaps teachers can incorporate them into their own teaching design.

4. The study methods of children's learning effectiveness and learning interest could to be refined

As mentioned in the literature discussion, the concept of fractions will be different at each school age. Fractions do not only mean that part of the quantity occupies the whole, but the concept of fractions will affect how students use fractions to solve problems. At present, this research only examines the pupils' recognition of fractions, their understanding of denominators and numerators, and their initial experience of different denominators and equivalent fractions. The test questions used have not been analyzed for validity, and the concept of fractions has not been comprehensively studied. Applied analysis, although it is limited by the low literacy rate of the first and second grade students and the lack of life situations, the use of these test questions to illustrate the effectiveness of the children's board game learning is also quite weak in argumentation. Therefore, researchers look forward to integrating tabletop games into formal teaching in the future. The learning effectiveness can be measured along with regular assessments of primary schools. The comparison between students who are integrated into the study of tabletop games and the samples that are not integrated into the study of tabletop games can be analyzed and compared. Yes, there should be more information about differences in learning effectiveness.

In addition, with regard to teachers who use board games to integrate mathematics teaching, what researchers expect is to enhance students' learning effectiveness and interest in learning, and it is also a proof of effective mathematics teaching. Therefore, whether it has an impact on the connotation of teachers' teaching content and knowledge should also be studied. One of the key points for the reader to understand deeply. After all, education has no other but love and role models. It can lead mathematics into an interesting subject, and teachers will guide pupils' interest in mathematics learning. In the future, we can conduct interviews with mathematics teachers who apply game-based teaching, analyze their differences, and use them as a basis for enhancing mathematics teachers' abilities.

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