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# How to Learn Multiplication Table While Having Fun

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**Abstract.** Teaching multiplication table is a central subject of mathematics in elementary school because complete memorization of the multiplication table is the foundation of the multiplication and division operations which are the prerequisite for developing mathematics skills. However, the complete memorization of the multiplication table is a boring and unenjoyable task for elementary school students. In this paper, we show how to have the students memorize the multiplication table without getting bored. Namely, we introduce a game application strengthening the students' memorizations of the multiplication table.

## 1. Introduction

There are many studies which report that the importance and difficulty of teaching multiplication table to elementary school students (we call them *pupils*) [1-3]. The multiplication table is one of the first and basic mathematical knowledge of the pupils. On the other hand, complete memorization of the multiplication table is a boring and unenjoyable task for the pupils (see e.g. [4]). This affects the difficulty of teaching multiplication table. Thus, it is required to provide a mechanism which strengthens pupils' memorization of the multiplication table without getting bored.

For the calculation of division, it is important to master the multiplication tables. Benesse Educational Research and Development Institute [5] reports that the average of correct answer rates of seven and eight times tables are 95.9% (the worst) and 96.1% (the second worst), respectively, in the calculation for multiplication table (in Japan). One of the possible reasons for this is that the pronunciations of "four", "seven", and "eight" in Japanese are somewhat similar. For example, pupils in elementary schools in Japan learn to pronounce "8 × 6" as "hachiroku" and "7 × 6" as "shichiroku", which makes it easy to mistake like "8 × 6 = 42". Indeed, the correct answer rate of "8 × 6" (resp. "7 × 6") is 90.7% (resp. 92.3%), while the average of all tables is 97.8%. Another example is that the correct answer rate of "3 × 4" is only 95.6%, while that of "4 × 3" is 98.7%, and the correct answer rate of "3 × 7" is rather low (97.2%). This is also because the pronunciations of "3 × 4" and "3 × 7" are rather similar: "sanshi" and "sanshichi", respectively. Another possible reason for the low average of correct answer rates of the seven times table is that all digits (except for 0) $i$ ($0 < i < 10$) appear as the first digits of the integers in the seven times table, that is, $\{\mathbf{7},1\mathbf{4},2\mathbf{1},2\mathbf{8},3\mathbf{5},4\mathbf{2},4\mathbf{9},5\mathbf{6},6\mathbf{3}\}$. Three has also the same property, but three is a small integer.

Against this background, we developed a game application for practicing simple division, which is helpful to master the multiplication tables. In order to understand division, the pupils must recognize the numbers in the multiplication tables [3]. Our game is designed so that pupils' memorization of the multiplication table is strengthened by repeating simple division. Our game application is targeted at pupils who have just learned the multiplication table. In this paper, we demonstrate how to have the pupils memorize the multiplication table without getting bored, by introducing our game application. The game application has the following properties:

1. The application makes the pupils become familiar with large divisors.
2. The application familiarizes the pupils with multiples of seven.
3. The application has a gimmick of promoting pupils' engagement with our game.

In the next section, we give more detailed explanations for those properties.

## 2. Details for Our Game Application

### 2.1 Overview of the Game Application

The aim of our game is to score by dividing given integers by their divisors. The given integers and their possible divisors are displayed on the pictures of wolves and the piglets, respectively. (See Fig. 1. Piglets are displayed on the lower side of the screen.) Hence, each given integer and a possible divisor are referred as to *wolf integer* (or simply wolf) and *piglet divisor* (or simply piglet) respectively. When starting the game, wolves come down from the top of the screen (See Fig.1). Each wolf is two-digits and can be expressed by $2^w \times 3^x \times 5^y \times 7^z$ for some non-negative integers $w$, $x$, $y$, and $z$. Thus, each wolf is at least 10 and at most 98, and its possible divisors are 2, 3, 4, 5, 6, 7, 8, and/or 9. A player should choose correct piglet divisors for each wolf integer, before arriving the wolf at the bottom of the screen, in order to attack the wolf (i.e. to divide the wolf integer by the chosen piglet divisors). When a piglet is chosen for a wolf, the piglet goes up toward the wolf and collides with the wolf. For a wolf integer, say $x$, if the player chooses a correct piglet divisor, say $y$, then the wolf integer is changed to the integer $x/y$. If $x/y$ becomes one, the wolf disappears from the screen, namely, the wolf is defeated, and then the player gains points. In Fig. 1, because there is no defeated wolf, the score is unchanged. If the player chooses a wrong integer (i.e. non-divisor), the wolf integer is unchanged. For example, for the most left wolf integer "40" in the left side of Fig.1, if a player chooses the piglet divisor "8" for the wolf, the wolf integer changes from 40 to 5 (= 40/5), that is, the wolf is damaged (see the right side of Fig.1). Players aim for a high score by defeating as many wolves as possible within the time limit (one minute).

### 2.1 How to Quickly Recognize Large Divisors

Many of the pupils who play the game application many times may realize that the numbers with the first digit being 0, 2, 4, 6, or 8 have two as its divisor, even though they cannot well calculate the division. Thus, a simple strategy for our game is that a pupil just chooses the piglet "two" for even wolves. For example, for the wolf "64", a pupil just chooses the piglet "two" successively. This is not desirable from a learning outcome perspective, because it is much better if the pupil chooses the piglet "eight". To avoid such a situation, the game application is designed so that the falling speed of a wolf depends on the wolf integer. That is, the larger the wolf, the faster the falling speed. The advantage of dividing by a larger piglet divisor makes pupils become familiar with large devisors.

### 2.2 The Multiples of Seven

As mentioned in the introduction, pupils tend to make more mistakes in the seven times table than in the other times tables. In order to familiarize the pupils with multiples of seven, in our application, the probability of producing a wolf of a multiple of seven is set a bit higher than that of the others.

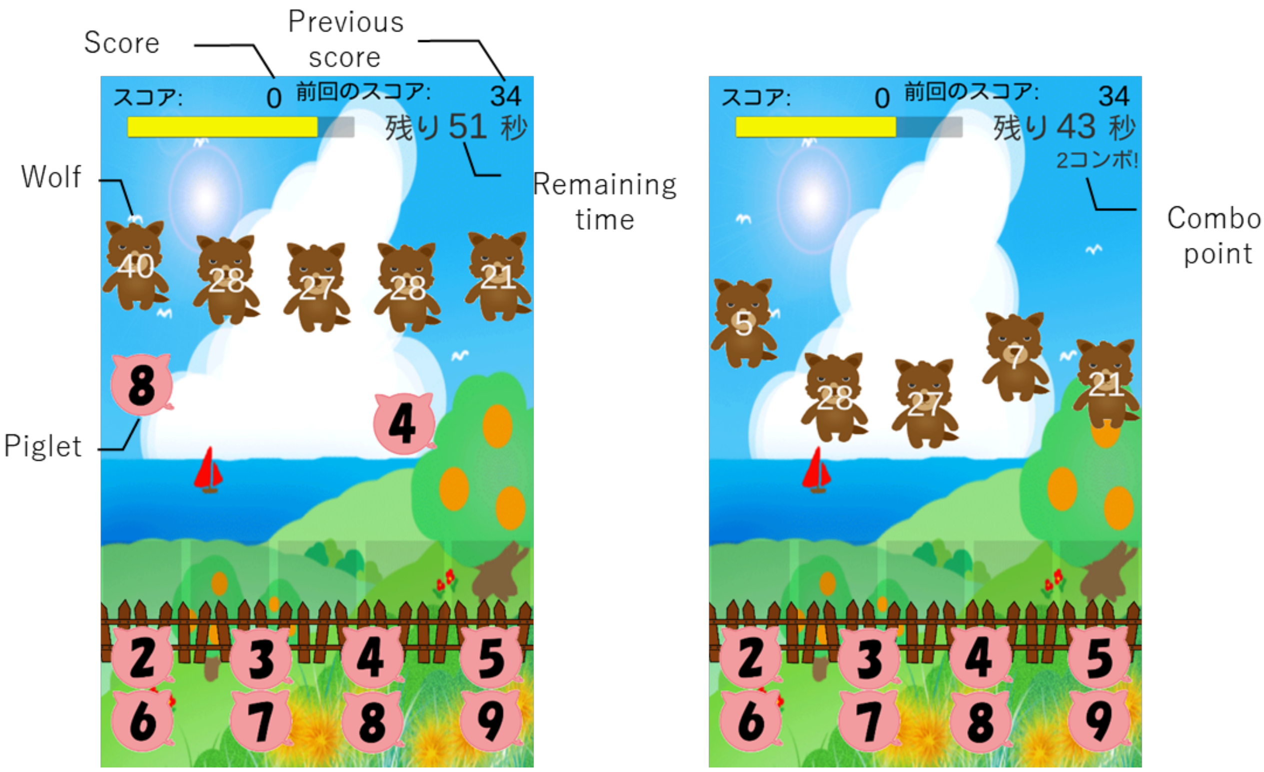


Fig. 1. Screen Shots of Our Game Application.

**2.3 Gimmicks of Promoting Pupils' Engagement with Our Game**

To promote the pupils' engagement, our application adopts a popular gimmick in the games, so-called *combo*: The *combo point* is added as long as a player consecutively chooses correct piglets. The point gained by defeating a wolf, that is, by making the wolf integer to be one, increases whenever the combo point exceeds preset thresholds. Fig.1 illustrates that the comb point increases from zero to two (see top right in the right side in Fig.1). Once the player chooses a wrong piglet, the combo is reset. Since there is no penalty for choosing a wrong piglet, the combo is an important role to prevent the pupils from choosing piglets without thinking deeply. While it is very important that there is no penalty for choosing a wrong piglet because the pupils can play without fear of failure. For pupils, it would be more suitable to use "carrot" rather than "stick". It is worth to mention that the strategy for the wolf "16" mentioned in subsection 2.1 is not a good strategy at higher levels, even though considering the combo because the falling speed is so fast.

The reason why we use wolves and piglets comes from the famous story "The Three Little Pigs". Since most pupils know the story, most of them can understand the purpose of the game with a very simple explanation. This is also an important point because nobody wants to read a manual to know how to play the game.

Our game has three levels. The higher the level, the faster the falling speed of the wolf becomes. Recall that each wolf is two-digits and can be expressed by $2^w \times 3^x \times 5^y \times 7^z$ for some non-negative integers $w$, $x$, $y$, and $z$. Every wolf in Level 1 is less than 50. Hence, all wolves in Level 1 appear in the multiplication table. Every wolf in Level 2 is less than 80. Thus, there are wolves of Level 2 that does not appear in the multiplication table. Only 75 ($=3 \times 5^2$) is such a non-trivial wolf (50, 60, and 70 are rather trivial). Every wolf in Level 3 is at most 98. Level 3 has 84 ($=2^2 \times 3 \times 7$), 96 ($2^5 \times 3$), and 98 ($=3 \times 7^2$), which do not appear in the multiplication table. Level 3 requires a prompt judgment of the *sharing*. Needless to say, it is needed to provide that they can play the game at their own level in order to promote pupils' engagement.

### 2.4 How Much Fun Our Game?

The game application was used at a two days event for children. In the event, more than 320 pupils played the game application. Approximately 10% of them answered a questionnaire. The questionnaire results show that most of them (30/36) enjoy the game and some of them answer that it is fun to play the game although the division is difficult. Some of them also answer that it is fun to get a better score. To keep their motivation, it is helpful to visualize their proficiency level as their score.

## 3. Conclusion and Future Work

In this paper, we introduced a game application, developed by us, which strengthens pupils' memorization of the multiplication table. Then, we demonstrated that pupils learn the multiplication table while playing the game. We plan to further evaluate the utility of our game application.

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