Fishing Master: An Educational Game for Number Sense of Mathematics Arithmetic for Elementary Students

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Abstract: Number sense, the basis of mathematical ability is the important goal of elementary mathematics curriculum. Previous studies have indicated that number sense may make student have the feeling of using numbers. It may help students understand the relationship of numbers more and judge the reasonableness of an answer. It can also enhance their ability of analysis. Students with better number sense can use various strategies to solve a problem. This study therefore designs a digital game, named Fishing Master, for facilitating students' number sense of addition. In order to win the game, students have to use appropriate strategies, which the system can scaffold them to use if they are not familiar with the strategies. In the future, the game should be improved and can be applied to multiplication and division for verifying its effects by a rigorous experiment.

Keywords: number sense, strategy use, game-based learning

Introduction

Number sense is an ability to recognize the meaning of numbers and to sense the relationship between numbers (Dehaene, 1997; NCTM, 1989; Stoddard, 1994; Thompson, & Rathmell, 1989). Previous research has demonstrated that even babies have such an ability (Dehaene, 1997), suggesting that number sense is inherent. However, although students have to deal with quantities in their daily life, they barely encounter abstract numbers, not to mention the relationships between numbers (Stoddard, 1994). Without number sense, students may find difficulties with effectively and efficiently solving problems, and even learning other subjects (Burton, 1993; Reys, 1991). For this reason, the main goal of mathematics education in primary schools should develop students' number sense.

In order to develop number sense, students need to practice seeing relationships between numbers, and to convert numbers into simpler forms (Stoddard, 1994). For the former, students can learn the properties of numbers. Ten's complement, for instance, may help them to do addition and subtraction more efficiently. For the latter, students can learn transforming numbers fluently. For instance, if a student can view 99 as 100-1, he/she may quickly calculate 273+99 by seeing 273+100-1, which are 372. Therefore, this paper aims to develop a mathematical game to facilitate students' number sense.

1. System design

This paper develops an educational game, called Fishing Master, for facilitating number sense. In this game, a student plays the role of a fisherman. He/she has to overcome all of urgent challenges in limited time. This game is implemented in HyperText Markup Language 5.0 with physics engine. In this game, the number of fishes determines the difficulty and the time required by the student. Previous research has showed that controlling the balance between the level of difficulty and the student's ability may arouse flow Experience, which may happen when people are totally absorbed in an activity (Csikszentmihalyi, 1990).

Figure 1. Interface of the game

1.1 Game rules

The game provides instructions. When the game starts, an arithmetic question appears at the top of the screen as shown in Figure 1. A student needs to calculate it and get the answer first. Then he/she as a fisherman has to catch some fishes with numbers which may assemble the answer as a shoal of fish. When the student becomes an experience fisherman, if fishes find someone wants to catch them, they may change their swimming directions and speed up in latter game levels. The game thus becomes more difficult catch in limited time. When a student passes one level, he/she may unlock one kind of fish (i.e. one number). Although he/she get one new option of assembling his/her answer, there are relatively more kinds of fish, which may hinder the student from catching his/her targets. For example, when the system detects the player becomes more capable, the bigger fish may obscure the smaller one because of their positions, making the game and calculation more difficult and challenging.

1.2 System architecture

Figure 2 illustrates the system architecture of the game. When a student enters a game level, the system may analyze the strategies that he/she used in previous levels. More specifically, the system classifies his/her strategies into several types, as shown in Table 1. If the student only uses a fixed or even inappropriate strategy, the system should scaffold him/her to use various and appropriate strategies for learning others number relationship

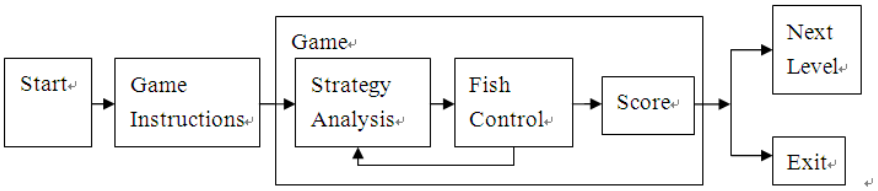

Figure 2. System architecture

Table 1 further shows the scaffolding that the system provides in order to facilitate number sense. The system may control the numbers on fishes to help player to learn and strengthen new strategies when detecting a student's strategy in his/her learning portfolios. For example, if the system detects that a student does not use grouping strategy, the system may provide a set of the same numbers (e.g. 5), and prompt the first three of them.

Table 1. Number sense strategy and system scaffolding

Strategy types	Definition	Scaffolding	Challenges
Ten's complement	Catching two numbers for making ten	(1) Providing more number pairs of 10 (2) Prompting the first pair	a. Providing 100's complement b. Providing near-10 number pairs (e.g. 5+6=11)
Grouping	Grouping the same numbers for approaching the answer	(1) Providing more same numbers (2) Prompting the first three same numbers	Providing more sets of the same numbers
Maximum first	Catching the maximum number first	Prompting the maximum number	N/A

2. Conclusion

This paper develops an educational game for facilitating number sense, which may help students understand numbers relationship, improve their problem-solving ability, as well as enhance their motivation. In this game, player plays a fisherman who uses various strategies to catch fishes with target numbers. However, this study is still in a preliminary stage, and need a rigorous experiment to verify the advantages mentioned above. From the perspective of games, the game can be improved by enhancing its freedom and flexibility to increase the playability in the future. From the perspective of learning, the game can be applied to multiplication and division to increase the diversity of learning.

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