

Development of 3D virtual math games on Second Life

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Abstract: Mathematical education in elementary school is the key fundamental of math learning. It plays an important role of pupils' future math learning. This study tries to combine information technology and mathematics to build a mathematical learning environment in Second Life. We expect to create a new learning style for mathematical education in elementary school. While Second Life has got a lot of empirical results in education, some researches indicate that students need guidance or teaching aids to learn in such environments. In order to improve the pupil's learning outcomes, this study proposes a problem-based learning approach with teaching aids and embeds mathematical learning materials in the built virtual classrooms facilitating teaching as well as learning.

Keywords: Second Life, problem-based learning, Math game, virtual classroom, teaching aids

Introduction

Mathematical education in elementary school is the key fundamental of math learning. It plays an important role in pupils' future math learning. According to Pólya's idea of *How to solve it* (1945), students need to know the meaning of a question and its goal before they solve a math question. Then, they have to think of strategies and plan a way to solve it. After they solve a question, they need to verify if the answer fits to the question and to think if there is a better answer. Pólya's idea looks simple. However, it is difficult to realize in educational field. Gu (1999) fingered out that even students already have the abilities to calculate a math question, they may still encounter the problem of understanding the meaning of math questions. According to the reasons above, we need teaching guidance to help students to understand the questions and solve them.

Schoenfeld (1985) pointed out that the major goal of mathematical education is to help students become a person with problem-solving ability. After famous Mathematician Pólya published *How to solve it*, *Mathematical discovery* and *Mathematics and plausible reasoning*, mathematics educators attach great importance to the tendency of math education. After all, training students to solve questions is an important task of math education, especially in the changing world. According to the ideas above, the main philosophy of the study is to design a problem-based teaching aids and materials which can help students to think and solve the math questions.

Living experiences are the best materials for students to learn. They learn in the environment which they are familiar with and they learn in daily life. *The Nuffield Foundation* (1965) proposed that I do and I understand at the beginning of the book. The author wrote Xi Wan Zhe Dong De Yi, which is the main concept of *The Nuffield Foundation* (1965), in Chinese in the introduction. Math games therefore become a trend and are improved with the progress of information technology. For example, interactive learning games, which are funny and interesting, can reduce students' fear of math and improve students' learning outcomes. Thus, this study use math games to design elementary math materials.

Since Second Life is easy to use and free to build (Boulos, Hetherington & Wheeler, 2007; Prasolova-Førland, Sourin & Sourina, 2006), it becomes a popular 3D platform in education field (Edwards, 2006). Besides, everyone can own his virtual environments, also called Sims, in Second Life. Therefore, many universities and language institutions (such as, British Council, Confucius Institute, Cervantes and Goethe Institute) have their own Sims, and do a lot of researches in SL. Although there are many empirical research results of education in Second Life, few emphases are put on math. Nevertheless, most of the mathematical learning materials are presented in 2D in digital learning. However, some materials are best presented in 3D. Since Second Life can present learning materials in 3D, we decide to do our mathematical teaching experiment in Second Life.

The objective of this study is to develop a new mathematical learning environment, combing information technology with mathematics. We develop 3D virtual math games based on Problem-based learning approach in the popular 3D virtual platform Second Life. The research questions of this study are described below:

1. Whether Problem-based learning approach can guide students in learning mathematics in Second Life?
2. Compare to those who do not study math based on Problem-based learning approach, do students study mathematics in Second Life in this study get better learning effectiveness?

1. Virtual math classroom

Most of the teachings in present are carried out in the classrooms. In this way, teachers will be able to handle students' learning progresses instantly. Besides, students can interact with their teachers closely in the class. However, this kind of face to face teaching has its limitations. For example, students have to go to the classroom to gain knowledge. For minorities or those who live in remote areas, they may not have the chance to gain knowledge because they may not be able to go to the classroom. On the other hand, distance learning breaks the limitation of time and space. Yet, it lacks of presence and sense of interaction. Students cannot immerse in distance learning because they watch educational videos most of the time and discuss with their peers via instant messages. To solve the above-mentioned problems, teaching in virtual environments becomes a trend in recent years. Therefore, we choose Second Life, a popular virtual platform, as our teaching environment. Second Life, a massively multiplayer online social game, is now applied into educational field extensively. It has vivid presence (Biocca & Levy, 1995) and provides the environment for cooperative learning and co-editing (Petrakou, 2009; Bishop, 2009). It is hoped that Second Life can help students immerse in online learning. The learning environments developed by us in Second Life are described as follows.

- Virtual classroom: The virtual classroom which simulates the real world classroom will help students get used to virtual learning environments quickly.
- Virtual platform: Teachers can teach on the platform and switch his slides here.
- Projector screen: Usually, there are one projector and one projector screen in traditional classroom. However, there are ten projector screens in these virtual learning environments. Students can see the projector screens from different directions.
- Podiums: There are podiums in front of students' seats. Students can raise their hands and vote in their seats.

With the help of above 3D learning environments, teachers can teach mathematics by slides, videos, voices or texts in Second Life which provides the environment for distance learning. Besides, Second Life also has vivid presence and sense of interaction.

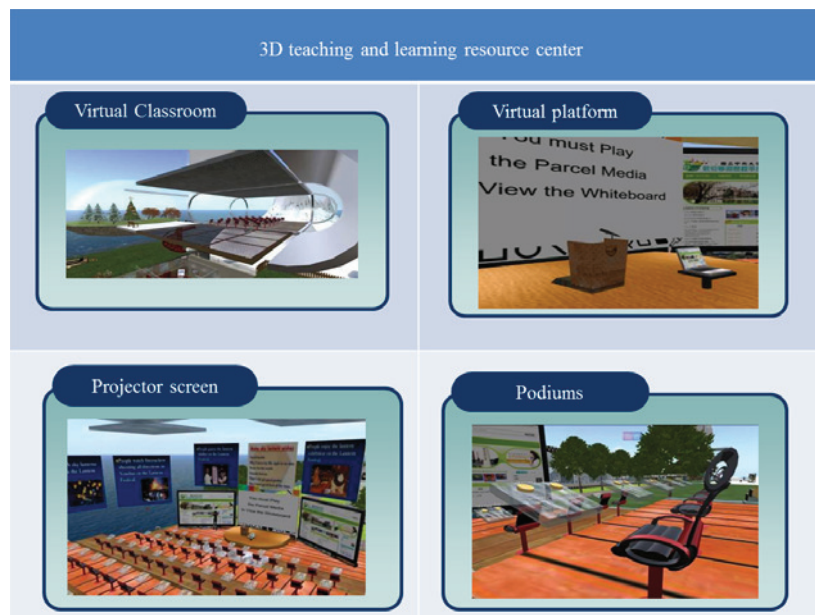


Figure1 Virtual teaching environment

2. Virtual math game

Previous research (Sang Joon Lee , 2011 ; Rovai & Downey , 2010 ; Wheeler , 2006) showed that teachings on online platforms such as Second Life might face the problem that students' learning motivations and learning effectiveness might be decreased because students cannot get learning guidance from teachers. Therefore, it is necessary to develop mechanisms or tools to guide students learning in 3D online environments. For example, University of Sussex designed a lot of learning tasks to increase students' interactions with others in Second Life. These learning tasks were designed based on Problem-based learning approach and Constructivism (Good, Howland & Thackray, 2008). Thus, we develop 3D virtual math games based on Problem-based learning approach in Second Life. These games are carried out in the way of scavenger hunt. We also develop a series of learning aids (table 2) to help students finish scavenger hunt.

Table 1 Scavenger Hunt

Scavenger Hunt	
There are three stages in the mathematical class. Students have to finish one task in each stage. If they can finish these tasks, they can watch movies in the theater in iTELL. The stages are described as follows:	
1. Class teaching	
First, the teacher will teach basic mathematical knowledge in the classroom in Second Life. In this way, students can learn mathematics in a way that is close to their previous learning experiences. In this stage, the teacher will teach with slides and talk to students with voice functions provided by Second Life.	
2. Doing scavenger hunt	
This study will build a test bank for student to do self-path learning. After students finish learning, they will do the scavenger hunt. They will first go to the supermarket in Second Life to go shopping. They will be told what to buy before they actually do the shopping. Then, they can buy the products and do arithmetic practices with the clerks so that they can learn mathematics in authentic environments. In addition, they can review what they have learned by in Second Life after class.	
3. Get awards or certification.	
After students finish their tasks, they can watch a movie in the theater, get awards or get certification.	

Table 2 Introduction to teaching aids

<p>1. Web PPT</p> <p>The slides for teaching are uploaded to the web server through the shared media function of Second Life viewer 2. In this way, the instructor can switch their slides at any time and save the charges for uploading slides. In addition, there are spaces for instructors to show their personal websites on the sides of the cube. Instructors can interact with students through these websites.</p>	
<p>2. The settings for buying products in the supermarket</p> <p>The products in the supermarket are provided with voices and texts. If students decide to buy a product, they would get an object so that they can pay for the product and practice supermarket checkout.</p>	
<p>3. HUD for collaborative learning</p> <p>To make full use of teaching resources in Second Life, we develop a set of teaching aids to assist students in learning. One of the teaching aids developed by us is HUD for collaborative learning. Students can take pictures in Second Life and upload their pictures to a php sever. They can wear HUD for collaborative learning to share pictures with their classmates. Even if students are in different places, they still can see the same picture and discuss it with each other. With HUD for collaborative learning, students can get guidance from teachers and tutors as well as get help from their classmates.</p>	

3. Conclusion and future research

This study aims to promote elementary students' learning effectiveness in mathematics. We design a virtual mathematical classroom, 3D problem-based mathematical materials and teaching aids to assist students in learning mathematics. It is expected that the methods proposed in this study can solve the lack-of-guidance problem and promote students'

learning effectiveness. To see whether 3D virtual mathematic games that are designed based on Problem-based learning approach can enhance students' learning effectiveness and whether Problem-based learning approach can assist students in learning mathematics, we design a series of mathematical experiments which will be done in an elementary school. Students will be divided into experimental group and control group. The control group will be taught by traditional teaching methods while the experimental group will be taught by the methods proposed in this study. The experimental results will show that whether the learning methods proposed in this study will enhance students' learning effectiveness.

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