

Using of Virtual Manipulatives on the Web-A Case Study of Four Elementary School Teachers

Yuan Yuan

yuan@cycu.edu.tw

Graduate School of Education

Chung Yuan Christian University

Abstract

Virtual manipulatives were proposed to be an innovative medium for use by elementary school children. The National Library of Virtual Manipulatives (NLVM) is an NSF supported project that began in 1999 to develop a library of uniquely interactive, web-based virtual manipulatives or concept tutorials for mathematics instruction. In this study, four elementary school teachers in Taiwan selected applets from NLVM and designed learning activities to apply in class. These explorations include using “Base Block” in grade 2, “Base Blocks Decimals” in grade 4, “Diffy” in grade 5, and “isometric Geoboard” in grade 5. Research result showed that students like to explore mathematics through the uses of these virtual manipulatives. Using of Virtual Manipulatives can improve students’ conceptual understanding, enrich exploration opportunities for higher achievers, and remedy weakness for lower learners. Because of the English interface, both teachers and students indicated difficulties in using these applets. It is hoped that these applets can be translated into Chinese. Regular workshops should be held to improve teachers’ abilities of designing learning activities.

Introduction

Physical manipulatives are known as useful tools in mathematics instruction. It is argued that they can be used as a media to promote students’ concrete thinking (Sowell, 1998). They offered alternative representations within which students could reconstruct concepts. Research showed that students who used manipulative materials in learning mathematics did perform better than those who did not (Raphael & Wahlstorm, 1989). However, existing physical manipulatives often have some problems of using in real classroom. These problems include lack of appropriate manipulatives, making classroom control problems, and cleaning and keeping problems. Recently, Moyer, Bolyard & Spikell (2002) proposed the feasibility of generating “virtual manipulatives” to present opportunities for constructing mathematical knowledge. This innovative technology is highly promising for use in learning and teaching mathematics. Virtual manipulatives are often exact visual replicas of concrete manipulates, and are placed on the Internet as applets. It was suggested that “Work with virtual manipulatives ... can allow young children to extend physical experience and to develop an initial understanding of sophisticated ideas” (NCTM, pp.26-27). Research also indicated that using virtual manipulatives helped children clarify their thinking and their usefulness for teaching mathematics was supported (Moyer, Niezgod, & Stanley, 2005).

However, it is important to investigate problems and questions of using virtual manipulatives in real classroom and to explore effective ways to use them in teaching mathematics.

Up to now, virtual manipulatives Web sites are not available in Taiwan. However, one well developed site can be found in USA - the National Library of Virtual Manipulatives (www.matti.usu.edu/nlvm). The National Library of Virtual Manipulatives (NLVM) is an NSF supported project that began in 1999 to develop a library of uniquely interactive, web-based virtual manipulatives or concept tutorials, mostly in the form of Java applets, for mathematics instruction (K-12 emphasis). Four graduate students took one of my graduate classes were introduced the concept of virtual manipulatives and the available resources. All of them are elementary school teachers, and they are interested in using these applets in classroom teaching. In this study, their applications of some of the applets from NLVM were studied. The ways to use virtual manipulatives were explored and problems were investigated for future study.

Method and Participants

This study applied a case study method to investigate the following two research questions:

1. What are some possible ways of using virtual manipulatives in real classroom?
2. What are problems of using virtual manipulatives in real classroom?

In this study, four elementary school teachers in Taiwan selected applets from NLVM and designed learning activities to enrich classrooms explorations. The selections of applets were based on these teachers' individual decisions. In other words, these teachers decided what and how to use a specific applet for their students. To protect the privacy of these teachers, I will not use their real names. These explorations included Mei-chi used "Base Blocks" in grade 2, E-fan used "Base Blocks Decimals" in grade 4, Fong-wei used "Diffy" in grade 5, and Kuo-jen used "isometric Geoboard" in grade 5.

These teachers took a graduate class of mine in year 2006. I used two class periods of time (a total of 6 hours) to introduce ideas and trends of integrating technology into mathematics teaching. Virtual manipulatives were introduced in class. It was found that these teachers were all interested in applying these applets to their class. I encouraged them to apply these applets in teaching mathematics and share their experiences in class. Four weeks later, they reported features of selected virtual manipulative and discussed results of using in teaching. During class time, all of the teachers shared their experiences of using virtual manipulatives in school. Suggestions of applications were also discussed to give rise to the conclusion of this study.

Results and discussions

In order to better understand the teachers' applications of virtual manipulative in NLVM, I will discuss these four cases individually. Then, reflections to these applications will be discussed at then end of this section.

1. Case one: Mei-chi used “Base Blocks” in grade 2

Mei-chi was a second-grader teacher. Two of her students, Yu-jen and Kuo-wa, often had difficulties in learning mathematics. In her observations, Yu-jen was not good at paper and pencil tests, and did not like to participate in leaning. However, Mei-chi found that Yu-jen was especially interested in multimedia and paid attentions to them. Kuo-wa had some developmental problems, and reading is a serious problem to affect his leaning. At the time of knowing the development of NLVM, she was teaching a unit called “numbers less than 1000”. She decided to use “Base Blocks” to help these two students. “Base Blocks” consist of individual units, longs (containing 10 units), flats (containing 10 longs), and blocks (containing 10 flats) and can be used to show place value for numbers and to increase understanding of addition and subtraction algorithms (see Fig. 1). Mei-chi used it to help Yu-jen and Kuo-wa understand numbers less than 1000.

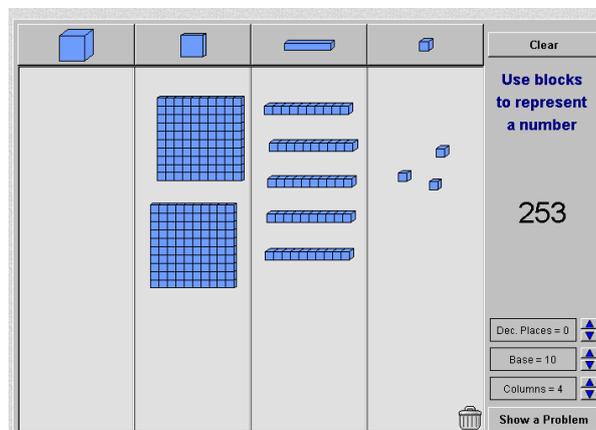


Fig. 1 “Base Blocks” shows place value for numbers

Before using this applet, Yu-jen and Kuo-wa can only finish 75% and 25% of test questions separately. After using this applet in learning, their test completion rates increased to 100% and 75% separately. Mei-chi described,

When Yu-jen was using “Base Blocks”, I saw smiling on his face. At this time, mathematics is not what he did not understand, and it is not just numbers and graphs. It is like a game, and he was interested in playing. After these explorations, he seemed to complete his test quickly and was more willing to do it.

On the other hand, Kuo-wa did not show his happiness as Yu-jen. It is possible because of his reading problems. He needed more time to complete his works, but under teacher’s guiding, he completed most of his test problems himself.

Mei-chi also said,

I knew integrating technology into learning is important and is a new trend, but this is the first time I knew there is a wonderful resource like this. I used it to these two students, and I found it reduced their fear of mathematics. I am happy to find a new way to improve their leaning of mathematics. Through seeing graphs, visual stimulus and manipulations with this virtual manipulative, mathematics is much easy to understand for these lower achievers. They are great!

The only problem of using this applet in instruction was its English interface. Mei-chi indicated that when using these applets the teacher will need much time in explaining their functions and students were easy to be affected by those unfamiliar icons. She believed that if they were in Chinese interface, definitely, they will be more acceptable by school teachers and students.

2. Case two: E-fan used “Base Blocks Decimals” in grade 4

E-fan was a fourth-grader teacher. The students in her class already knew the relationship between 0.1 and 0.01. Also, they knew how to represent 0.13 on a 10x10 grid. Before using “Base Blocks Decimals”, her class had explored some basic decimal concepts with 10x10 grids. These explorations included the comparisons of 2 decimal numbers, the relationships between 2 decimal numbers, and additions and subtractions of decimal numbers. After these initial explorations, E-fan found some misconceptions her students had. For example, 10 of 35 students considered the number 4.68 was bigger than 4.8. They computed the sum of two decimals by lining up the right-hand digits, as they would with whole numbers. E-fan decided to use “Base Blocks Decimals” to help students clarify these concepts.

In E-fan’s point of view, clean and clear were two characteristics of this applet. In the previous classes, she remembered her students’ tables were full of 10x10 grids and students did not pay attentions to her explanations. Students also responded that they liked to use this applet. They thought it was fun and convenient. They did not need to worry about loses of paper grids. In addition to these, they had chances to practice computational skills. However, problems occurred when using it in instruction. E-fan found students had a problem to choose 10 units at a time, especially when there were units near the corner (see Fig. 2.)

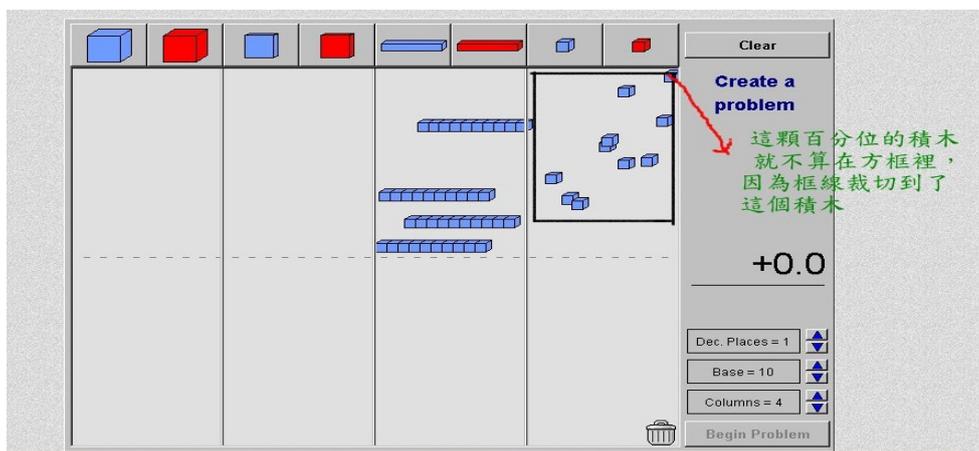


Fig. 2 using problem of choosing a unit on the corner

The other problem occurred when graphs were overlapped. Students often had a problem to separate and count them correctly (see Fig. 3).

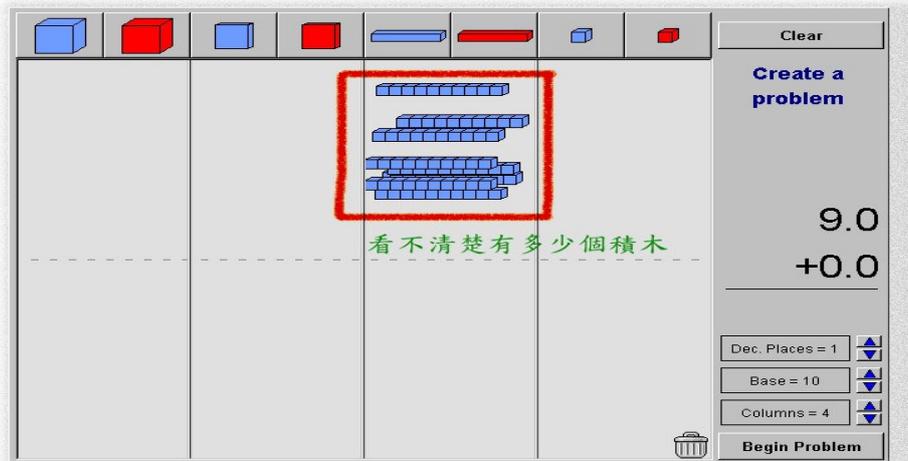


Fig. 3 Students had a problem to figure out the number of flats on the monitor E-fan also found new misconceptions student might have after using this applet. For example, when asked how many 0.01 equals to 0.1? Students gave the correct answer, but the graph they drew on paper was affected by this applet (see Fig. 4).

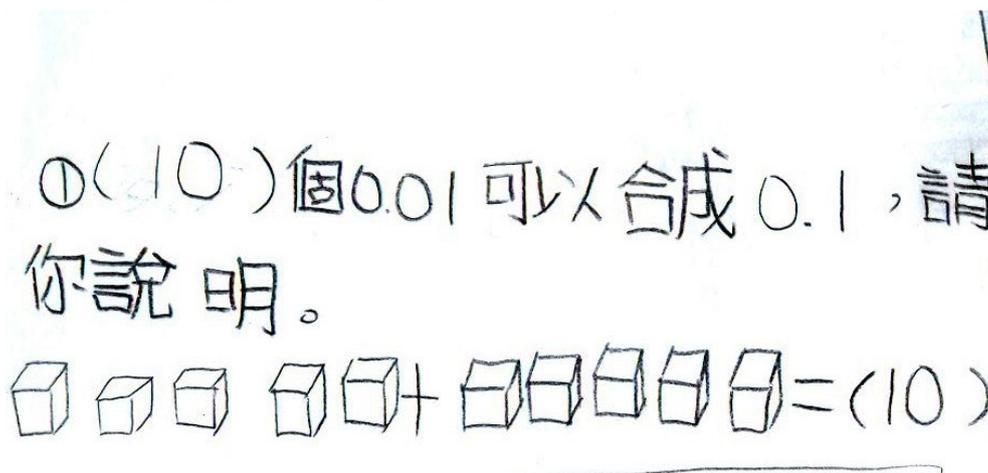


Fig. 4 Student used a cube to represent 0.01

E-fan also mentioned that the interface might affect students' learning. For example, the applet used 1/100's to represent the hundredths and students were not familiar with this representation. She also suggested the interface should be in Chinese, so students could be easy to understand. Even with the difficulties of understanding the meaning of icons, almost all her students (34 of 35) explained their love of learning with "Base Blocks Decimals".

3. Case three: Fong-wei used "Diffy" in grade 5

Fong-wei was a fifth-grader teacher. There are two gifted students in her class, so she decided to find a challenge activity from NLVM for them to explore. "Diffy" is a virtual manipulative selected from number and operations for grade 3-5 students. It is designed to give students a chance to solve an interesting puzzle involving the differences of given numbers (see Fig. 5).

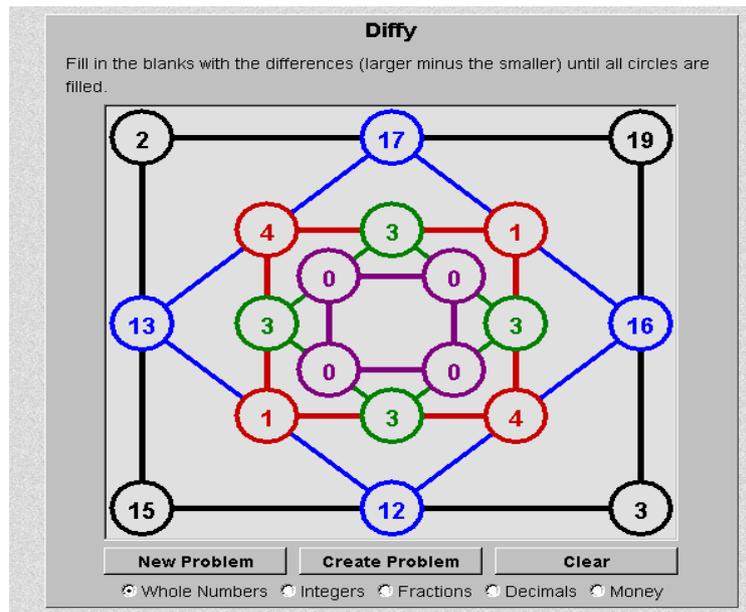


Fig. 5 “Diffy”- a puzzle for exploring patterns

The two students were introduced this applet and asked to find all possible arrangement of 4 numbers between 1 to 10 to make 7 squares where the inner square has four puzzle numbers that are all the same. For example, figure 6 gives an example of this result.

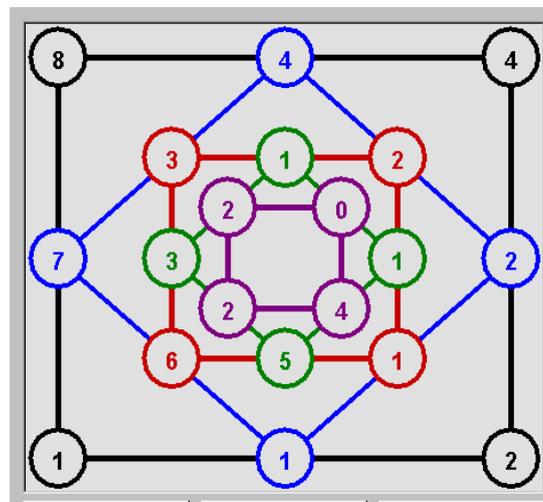


Fig. 6 An example that satisfies the requirement

Although figure 6 showed an example of this result, this graph did not complete the works. There should be another two squares with number 2,4,2,0 and 2,2,2,2. That is, the teacher asked the students to explore a problem that the applet cannot show completely. Fong-wei reported that these two students were not interested in using this applet. They seemed to prefer drawing on paper. It was found these two students were interesting in finding answers and they did have some amazing findings. They spent a lot of time drawing and trying. However, there was a lack of pattern explorations.

This activity did motivate students' experiences in exploring questions different from the textbook. But this applet was not used appropriately. More important, if the teacher could spend a little time on reading instructions on the Web, she might design an appropriate activity for these two students. For example, there are two questions suggested for users: (1) What kinds of patterns can you see in the purple numbers when you complete Diffy? (2) Will you always get some zeros in the purple numbers, or a set of four purple numbers that are all the same, or two pairs of matching purple numbers? When a teacher proposed appropriate questions for students to explore, they may focus on what we want them to find.

4. Case four: Kuo-jen used "isometric Geoboard" in grade 5

Kuo-jen was a fifth-grader teacher. He was going to teach the concept of polyhedron. Before using "isometric Geoboard", the teacher conducted a pretest to assess students' understanding of polyhedron. After pretest, the teacher asked students make different polyhedra with "isometric Geoboard". During a consecutive two class periods of time, students went to the computer room and making polyhedra by themselves. The teacher designed tasks for them to explore and asked students to complete tasks without any future lectures in class. Figure 7 were some results of students' works. Figure 8 was a picture that students worked hard to complete the required task their teacher asked during class time. Kuo-jen mentioned that he was so surprised that his students never worked hard like this before. After this activity, students were given a posttest. The test mean score increased from 79.54 to 89.49. Using pair sample t test to test the difference, there was a significance of difference between pretest and posttest ($t=-7.429, p<.001$). It showed that students' test score improved after the instruction. Thirty-three of 35 students responded that using this applet helped their leaning of this unit. Twenty-eight students described their love of using a computer to learn mathematics.

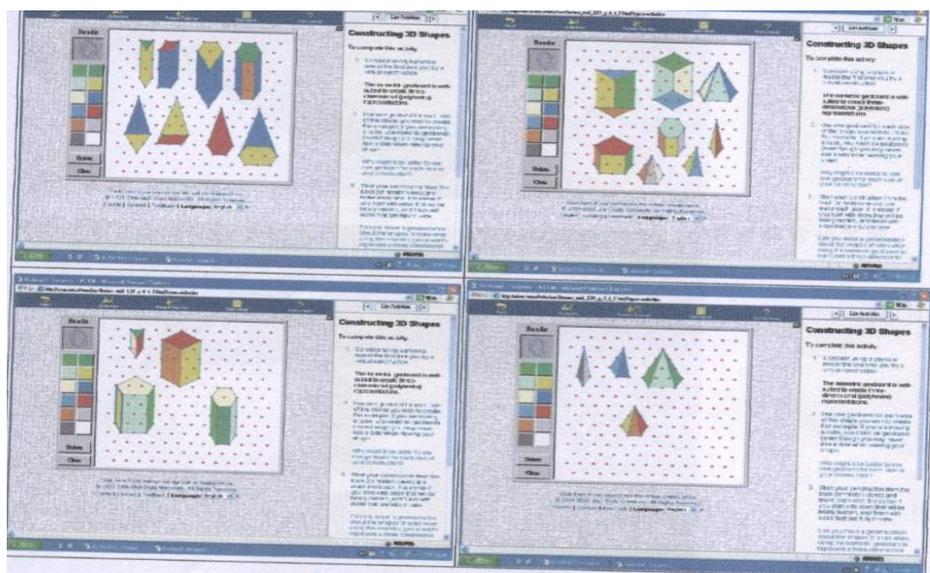


Fig. 7 Students' works on using "isometric Geoboard"



Fig. 8 Students worked hard to complete the tasks

Kuo-jen reported his experiment in class and the result excited discussions in my class. Although students' test scores were improved, all teachers argued this to be the learning effect. No matter what strategies the teacher used, students should learn from instruction. So this result was not surprising. All teachers in my class gave ideas of using this applet in instruction. They seemed to argue the role of the teacher in using this applet. In our experiences, students liked to learn from computers. Whether they like using computer or like learning mathematics from computers was not clear. In discussion this application, we believed that "isometric Geoboard" could be used more efficiently.

5. Reflections to the cases study

Four teachers were happy to know the idea of using virtual manipulatives to teach mathematics. Without any discussions in advance, the teachers used virtual manipulatives differently. They used virtual manipulatives to students with different abilities – lower achievers and high achievers. They also used virtual manipulatives to introduce new concepts or to enrich a deep understanding of a concept. There was no doubt that these teachers and their students liked to have a chance to explore mathematics with virtual manipulatives. A few suggestions were summarized as following:

- (1) School teachers need to know how to design activities for using virtual manipulatives in instruction.
- (2) Possible problems of using virtual manipulatives should be studied. This information also should be notified to all the users.
- (3) The available virtual manipulatives on Web sites should be translated into different languages for different language users.
- (4) There should be a team working on the development of virtual manipulatives in Taiwan.

Using virtual manipulatives in instruction is a new trend of integrating technology into mathematics teaching and learning. However, using it is not a panacea. They should not be used as

substitutes of all traditional teaching aids. School teachers need to choose appropriate teaching aids (both physical and virtual manipulatives) in accordance with the curriculum to promote the efficiency of their mathematic teaching.

Conclusion

Numerous virtual manipulative Web sites are currently available in many countries. Many advantageous properties about virtual manipulative had been discussed. They are “the potential for alteration”, “interactivity”, “link symbolic and iconic notation”, “unlimited supply”, and “easy to clean” (Moyer, Bolyard, & Spikell, 2002). What is important is to study the usefulness of virtual manipulatives. This research studied the use of virtual manipulatives from NLVM. Research result showed that students like to explore mathematics through the uses of these virtual manipulatives. Using of virtual Manipulatives can improve students’ conceptual understanding, enrich exploration opportunities for higher achievers, and remedy weakness for lower learners. Virtual manipulatives could be used differently in mathematics instructions. However, new misconceptions might occur when using these applets in real classroom. This information is important for school teachers. It should be a research focus in the future.

In this study, I also found these teachers did not read the instructional suggestions provided by designers of virtual manipulatives. They seemed to spend a lot of time designing activities by themselves. On one hand, this is good because they did prepare for the lessons. On the other hand, this also showed that the teachers did not adopted good ideas to apply these applets to their classroom teaching. These teachers seemed to have difficulties of reading instructions in English, even though they are graduate students. I believed this is true to most of elementary school teachers in Taiwan. In this study, both teachers and students also indicated difficulties in using these applets because of the English interface. It is hoped that these applets can be translated into Chinese interface. Regular workshops should be held to improve teachers’ abilities of designing learning activities. By the way, we also require a team to develop virtual manipulatives for teachers in Taiwan.

(Support for this work was provided by grants 95-2520-S-026-003 from the National Science Foundation. The opinions expressed, however, are those of the author and do not necessarily reflect the views of the foundation.)

Reference

- Moyer, P. S., Bolyard, J. J., & Spikell, M. A. (2002). What are virtual manipulatives? *Teaching Children Mathematics*, 8, 372-377.
- Moyer, P. S., Niezgod, D. & Stanley, J. (2005). Young children’s use of virtual manipulatives and other forms of mathemat Elliott (Eds.), *Technology ics representations*. In P. C. -supported mathematics learning environments (Sixty-seven yearbook). Reston, VA: NCTM.

- National Council of Teacher of Mathematics (2000). Principles and standards for school mathematics. Reston, VA: NCTM.
- Raphael, D. & Wahlstorm, M. (1989). The influence of instructional aids on mathematics achievement. *Journal for Research in Mathematics Education*, 20, 173-190.
- Sowell, E. J. (1998). Effects of manipulative materials in mathematics instruction. *Journal of Research in Mathematics Education*, 20, 498-505.