EFFECTS OF VIRTUAL MANIPULATIVES ON STUDENTS’ PROCEDURAL KNOWLEDGE AND CONCEPTUAL UNDERSTANDING OF FRACTIONS

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EFFECTS OF VIRTUAL MANIPULATIVES ON STUDENTS’ PROCEDURAL KNOWLEDGE AND CONCEPTUAL UNDERSTANDING OF FRACTIONS

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EFFECTS OF VIRTUAL MANIPULATIVES ON STUDENTS’ PROCEDURAL KNOWLEDGE AND CONCEPTUAL UNDERSTANDING OF FRACTIONS

ABSTRACT

George Tan Geok Shim

The advancement in technology has dramatically changed the daily life of people around the world. In the past decade, computer technology has not only changed the nature of resources, communication, and information; it also transformed the contemporary society; changing the ways we live, work and learn (Hill & Hannafin, 2001; cited in Mcgrawl, 2005). Recently, the use of computers in mathematics classroom has increased as educators begin to see them as valuable teaching tools. An idea to create “virtual manipulatives” was proposed by Moyer, Bolyard and Spikell (2002; cited in Yuan, 2007) to present opportunities for constructing mathematical knowledge. Virtual manipulatives are replicas of physical manipulatives placed on the World Wide Web in the form of computer applets with additional advantageous features (Moyer & Reimer, 2005). One feature that makes virtual manipulative applets advantageous for mathematics instruction is their capability to connect dynamic visual images with abstract symbols. The purpose of this study was to examine the effectiveness of using virtual manipulatives in the teaching and learning of primary five fractions. This study explored the impact of virtual manipulatives on students’ mathematics achievement, attitudes towards virtual manipulatives, and interest in learning mathematics. In addition, this study also investigated the changes in students’ procedural knowledge and conceptual understanding of fraction using virtual manipulatives. The study was conducted using a pretest-posttest quasi-experimental with control group design. The independent variables were the instructional approaches (virtual manipulatives and traditional instruction) and students’ gender (male and female). The dependent variable were the students’ mathematics test score (procedural knowledge and conceptual understanding), students’ attitudes towards the instructional approaches, and students’ interest in learning mathematics. The covariate was the students’ initial procedural knowledge and conceptual understanding of fractions. The participants for this study were one hundred and twelve primary five students from two national primary schools in Kota Samarahan, Sarawak. The research instruments used in this study comprised of pretest, posttest, and questionnaire. Data obtained were coded, computed, and analyzed using the Statistical Packages for the Social Science (SPSS) version 16. Results showed that students that were taught using virtual manipulatives have better procedural knowledge and conceptual understanding compared to students that were taught using traditional instruction. There was also a significant gender difference in students’ procedural knowledge, with female students having a better procedural knowledge achievement scores compared to male students. Furthermore, students in the virtual manipulatives group have positive attitudes toward the instructional approaches and more positive interest in learning.
mathematics compared to the students in the traditional instruction group. Thus, it could be concluded that virtual manipulatives has the potential to improve learning in primary mathematics classes.
KESAN MANIPULATIF MAYA TERHADAP PERMAHAMAN PROSEDUR AND PERMAHAMAN KONSEP PECAHAN

ABSTRAK

George Tan Geok Shim

manipulatif maya mempunyai sikap yang lebih positif terhadap kaedah pengajaran dan minat positif dalam pembelajaran matematik berbanding dengan pelajar dalam kumpulan pengajaran tradisional. Oleh yang demikian, boleh disimpulkan manipulatif maya mampu mempunyai potensi untuk meningkat pelajaran dalam kelas matematik sekolah rendah.
CHAPTER ONE
INTRODUCTION

1.0 Introduction

This chapter is divided into nine main sections. Section 1.1 provides the background of the study. Section 1.2 discusses the problem statement of this study. Section 1.3 provides the objectives of the study. This is then followed by Section 1.4, which discusses the research questions of the study. Section 1.5 provides the research hypotheses of the study. Section 1.6 gives an overall view of the research through the research framework of the study. The next section, Section 1.7, provides the meanings and definitions of various terms used in this study. Section 1.8 discusses the importance and significance of the study. This is followed by Section 1.9 which lists the limitations of this study. Lastly, Section 1.10 summarises the chapter.
1.1 Background of the Study

The rapid advancement of technology has dramatically changed the daily life of people around the world. In the past decade, computer technology has not only changed the nature of resources, communication, and information; it also transformed the contemporary society; changing the ways we live, work and learn (Hill & Hannafin, 2001; cited in McGraw, 2005). Computers are powerful cognitive tools because of their computational power and the capacities to present information and organise information in multiple format and mode (Chee & Wong, 2003). As a classroom tool, the computer has captured the attention of the education community where this versatile device can store, manipulate, and retrieve information and it has the capability not only of engaging students in instructional activities to increase their learning but of helping them to solve complex problems to enhance their cognitive skills (Jonassen & Reeves, 1996; Newby, Stepich, Lehman, & Russel, 2001; both cited in Bauer & Kenton, 2005).

Technology has contributed significantly to mathematical learning, and the nature and extent of its contribution depends largely on the technology adopted (Clement & Sarama, 2005; cited in Yuan, 2005). Recently, the use of computers in mathematics classroom has increased as educators begin to see them as valuable instructional tools. Computers have made life easier for mathematics educators and people doing mathematics with the help of several software packages capable of word-processing and making difficult mathematics calculations and drawings (Durmus & Karakirik, 2006). With recent advances in computer technology, it is no surprise that the manipulation of objects in mathematics classrooms now includes the manipulation of objects on the computer screen (Moyer & Reimer, 2005), which implies that
the mathematics manipulatives are slowly changing from concrete or physical manipulatives to virtual manipulatives. An idea to create "virtual manipulatives" was proposed by Moyer, Bolyard and Spikell (2002; cited in Yuan, 2007) to present opportunities for constructing mathematical knowledge. This is an exciting technology for use in teaching mathematics especially in elementary schools. Virtual manipulatives are essentially replicas of physical manipulatives placed on the World Wide Web in the form of computer applets with additional advantageous features (Moyer & Reimer, 2005). Basically, they are virtual images on the computer and can be dynamically manipulated in the same manner as a concrete manipulative (Yuan, 2005). According to Moyer, Niezgoda, and Stanley (2005; cited in Yuan, 2005), children can use computer mice to manipulate the images and these developments are due to innovations in computer technology that enable programmers to generate electronic objects.

One feature that makes virtual manipulative applets advantageous for mathematics instruction is their capability to connect dynamic visual images with abstract symbols. It is specifically useful for those students who have difficulties in connecting abstract mathematics symbols and concrete experience (Yuan, 2007). Virtual manipulatives also highlight important instructional aspects or features of individual manipulatives, provide links to related web-based resources, and have the potential to record user movements through stored procedures within each application (Dorward & Heal, 1999; cited in Drickey, 2000). Using manipulatives as cognitive tools could improve the teaching and learning process, and encourage student reflections on retaining the information.

Virtual manipulatives also improved students' procedural knowledge and conceptual understanding in mathematics (Moyer & Reimer, 2005). According to Berretta (2008), procedural knowledge refers to mastery of computational skills and conceptual understanding
refers to the knowledge of the underlying structure of mathematics. Both procedural knowledge and conceptual understanding are considered necessary aspects of mathematical understanding, thus, to teach mathematical understanding one must include teaching for both procedural knowledge and conceptual understanding (Wearne & Hiebert, 1988; cited in Berretta, 2008).

1.2 Statement of the Problem

According to Schoenfeld (2002; cited in Hawkins, 2007), many students are achieving at level lower than their expected grade level in mathematics and this is the reason why teachers need to examine new ways to teach mathematics concepts and skills to enable students to achieve at a higher level. As technology tools such as computers become increasingly common in schools, teachers should take advantage of them in teaching students in schools. Teachers should integrate the use of computer programs in their teaching as it is convenient and could attract students’ interest in the learning mathematics. Teacher should also be aware about the potentials of using manipulatives in the teaching of mathematics. There are growing evidences showing that mathematics manipulatives can have a positive effect on mathematics achievement in schools (Crossley, 2003), including enhancing students’ understanding of mathematics (Drickey, 2000). McClung (1998; cited in Battle, 2007) also found that the use of manipulatives produces greater mathematics achievement than a lesson not incorporating them. With the advances in computing technology, it is logical for educators to translate the concept of physical manipulatives into a virtual medium. While physical manipulatives are believed to improve children’s understanding of mathematics concepts (Bohan & Shawaker 1994; Burns, M. 1996; Fueyo & Bushell 1998; all cited in Brown, 2007; Drickey, 2000),
Virtual manipulatives are also emerging as powerful instructional tools. Although virtual manipulatives are still relatively new in mathematics education, some research studies do showed that students' learning in mathematics improved after using the virtual manipulatives (Drickey, 2000). According to Brumbaugh and Hodge (2003), teachers can attest to the value of manipulatives especially for children in the primary grades who need the concrete exposure that manipulatives provide. Furthermore, it has also been reported that older children can likewise benefit from the use of manipulatives (Brumbaugh & Hodge, 2003).

Research has showed that students have difficulties in learning some mathematics topic such as fractions. According to Suh (2005), students often have less out-of-school experiences with fractions than with whole number. Besides that, students are not as fluent in operating with rational numbers as they are with whole numbers. For example, on the National Assessment of Education Progress (NAEP), also known as "the Nation's Report Card", only 50% of 13 year olds correctly completed problems such as $3\frac{1}{2} - 3\frac{1}{3}$, and $4 \times 2\frac{1}{2}$, and one conclusion that was drawn from the result was that by age 13 many students have not fully developed procedural fluency (National Research Council, 2001; cited in Suh, 2005). Hence, this makes it necessary for teachers to provide relevant experiences to enhance students' informal understanding of fractions and help to improved students' procedural knowledge and conceptual understanding in fractions. A search in PERPUN (Perpustakaan Negara) website indicated minimal work has been done on investigating the usefulness of virtual manipulatives in the context of mathematics education in Malaysia. Hence, the purpose of this study was to examine the effectiveness of using virtual manipulatives in the teaching and learning of primary five fractions. This study explored the impact of virtual manipulatives on students' mathematics achievement, attitudes toward instructional approaches and interest in learning.
mathematics. In addition, this study also investigated the changes in students’ procedural knowledge and conceptual understanding of fractions when using virtual manipulatives.

1.3 Research Objectives

The main objective of this study was to determine whether the use of virtual manipulatives would result in better achievement among primary five students in the teaching and learning of fractions. Specifically, this study looked at the following research objectives:

Research Objective 1: To determine:

i. the main effects of the instructional approaches (virtual manipulatives and traditional instruction) on students’ procedural knowledge in the topic of fractions.

ii. the main effects of students’ gender (male and female) on students’ procedural knowledge in the topic of fractions.

iii. the interaction effects of the instructional approaches and students’ gender on students’ procedural knowledge in the topic of fractions.

Research Objective 2: To examine:

i. the main effects of the instructional approaches (virtual manipulatives and traditional instruction) on students’ conceptual understanding in the topic of fractions.

ii. the main effects of students’ gender (male and female) on students’ conceptual understanding in the topic of fractions.

iii. the interaction effects of the instructional approaches and students’ gender on students’ conceptual understanding in the topic of fractions.
Research Objective 3: To investigate differences in students’ attitudes toward the instructional approaches.

Research Objective 4: To determine differences in students’ interest in learning mathematics based on the instructional approaches.

1.4 Research Questions

Thus, this study examined the following research questions:

Research Question 1:

i. Were there any main effects of the instructional approaches (virtual manipulatives and traditional instruction) on students’ procedural knowledge in the topic of fractions?

ii. Were there any main effects of students’ gender (male and female) on students’ procedural knowledge in the topic of fractions?

iii. Were there any interaction effects of the instructional approaches and students’ gender on students’ procedural knowledge in the topic of fractions?

Research Question 2:

i. Were there any main effects of the instructional approaches (virtual manipulatives and traditional instruction) on students’ conceptual understanding in the topic of fractions?

ii. Were there any main effects of students’ gender (male and female) on students’ procedural knowledge in the topic of fractions?
iii. Were there any interaction effects of the instructional approaches and students' gender on students' conceptual understanding in the topic of fractions?

Research Question 3: Were there any differences in students' attitudes toward the instructional approaches?

Research Question 4: Were there any differences in students' interest in learning mathematics based on the instructional approaches?

1.5 Research Hypotheses

This research has eight research hypotheses based on the research questions stated:

H_01(i): There were no main effects of the instructional approaches (virtual manipulatives and traditional instruction) on students' procedural knowledge in the topic of fractions.

H_01(ii): There were no main effects of students' gender (male and female) on students' procedural knowledge in the topic of fractions.

H_01(iii): There were no interaction effects of the instructional approaches and students' gender on students' procedural knowledge in the topic of fractions.

H_02(i): There were no main effects of the instructional approaches (virtual manipulatives and traditional instruction) on students' conceptual understanding in the topic of fractions.

H_02(ii): There were no main effects of students' gender (male and female) on students' conceptual understanding in the topic of fractions.