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UTILIZATION OF VIRTUAL MANIPULATIVES IN TEACHING FRACTIONS: INPUTS FOR DEVELOPMENT OF SELF INSTRUCTIONAL MATERIALS

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I. Context and Rationale

Fraction is one of the basic but poorly understood concepts in Mathematics in elementary school curriculum.In 12 years of teaching, I always noticed that the students tend to avoid questions or problems with fractions. In my certain topic, I always integrate my examples and given to integers, decimals, and fractions. But only in fractions they are having difficulties, specifically, addition and subtraction of fractions. It maybe because of some rules to follow and there are some pre- requisite topics prior to the lesson. Since there are fixed list of targets of lessons to be discussed by the teachers and competencies to be acquired by the students in a school year, the teachers tend to follow and finish the designed curriculum in the allotted time, compromising the quality of learners they are producing. A fraction does not represent a specific amount, but rather it represents a portion of an amount. Research showed that fractions were among the most difficult mathematical concepts to master (Behr, Harel, Post, & Lesh, 1992; Bezuk & Cramer, 1989; Moss & Case,1999).

Students need to be actively involved in their learning and manipulate objects in their surrounding so that they can generate better understanding of fractions with the help of appropriate manipulative, specifically, virtual manipulative.Ideally, students should be given opportunities to explore the fractions concept through hands-on experiences, share their ideas among themselves and more importantly to learn addition and subtraction of fractions with the help of appropriate manipulatives.

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II. Review of Related Literature

Development of Mathematics

Throughout the earlier centuries of human civilization, mathematical developments were triggered largely by basic social and economical needs. Gradually, mathematics grew into a discipline having scientific, financial and statistical applications. Furthermore, mathematical thought was enriched by people who explored the philosophical and aesthetic aspects of mathematics.

The twentieth century has brought about unprecedented innovations in many aspects of human civilization. With the start of the new millennium, we are witnessing dramatic changes in a way we live, work and learn. Our educational systems are struggling to cope with these changes, yet at times the pace is too quick. To be effective, changes is doing things require changes in the way we perceive them (Atallah, 2010).

New philosophies of mathematics education are evolving in response to a rapidly changing world. Mathematics education now viewed by some as a means to: "equip people with the knowledge and tools that will enable them to examine and criticize the economic, political and social realities of their lives" (Zaslavsky, 1994).

No generation is more at ease with online, collaborative technologies than today's young people, digital natives, who has grown up in an immersive computing environment. Where a notebook and pen may have formed the tool kit of prior generations, today's students come to class armed with smart phones, laptops and iPods.

To have students a good foundation on math, teachers deserve respect, more autonomy and opportunities to further their own content knowledge for teaching. Educators should be experimental and take risk in their approach.

Technology in Teaching Mathematics

According to the report from the Economist Intelligence Unit Sponsored by the New Media Consortium, technology is enabling multi-modal teaching, changing curricula and spawning rich forms of online research and collaboration, nearly 60% of survey respondents say that professor will soon teach in more than one medium. According to the survey, online collaboration tools, software that supports individually paced learning, and learning-management systems are among the communications technologies most expected to improve academics over the next five years. Web 2.0 technologies such as wikis, instant messaging and social networking—which have been influential in improving connectivity in many settings and are in use now at a large number of institutions—are expected to decline in use over that period.

Based on the study, "The Impact of Digital Technology on Learning" by Professor Steven Higgins, ZhiMin Xiao and Maria Katsipataki School of Education, Durham University, the research over the last forty years about the impact of the technologies on learning consistently identifies positive benefits. The increasing variety of digital technologies and the diversity of contexts and settings in which the research has been conducted, combined with challenges in synthesizing evidence from different methodologies, makes it difficult to identify clear and specific implications for educational practice in schools. Research findings from experimental and quasi-experimental designs – which have been combined in meta-analysis – indicate that technology-based interventions tend to produce just slightly lower levels of improvement when compared with other researched interventions and approaches (such as peer tutoring or those

which provide effect feedback to learners). The range of impact identified in these studies suggests that it is not whether technology is used (or not) which makes the difference, but how well the technology is used to support teaching and learning. There is no doubt that technology engages and motivates young people. However this benefits is only an advantage for learning if the activity is effectively aligned with what is to be learned.

Virtual manipulatives are essentially replicas of physical manipulative placed on the World Wide Web in the form of computer applets with additional advantageous features. Moyer, Bolyard, and Spikell (2002) define a virtual manipulative as "an interactive web-based visual representation of a dynamic object that presents opportunities for constructing mathematical knowledge". Researchers and educators have argued that the mere use of manipulative does not guarantee that students will understand concepts and procedures and be able to connect these concepts to abstract symbols without teachers making these connections explicit (Moyer, 2001). In other words, simply using the manipulative does not insure learning.

One feature that makes virtual manipulative applets advantageous for Mathematics instruction is their capability to connect dynamic visual images with abstract symbols – one limitation of physical manipulative. Unlike physical manipulative, electronic tools use graphics, numbers, and words on the computer screen to connect the iconic with the symbolic mode (Kaput, 1992). For example, a base-10 blocks applet may show both the visual representations of the blocks and, at the same time, show the number of hundreds, tens, and ones in a place-value notation. These pedagogical notations provide support that bridges students' manipulations of the virtual blocks with the formal symbolic system, and this connection holds promise for improving student learning. It is a challenge to find research that specifically describes and documents work in classrooms with virtual manipulative. One of the reasons for this lack of information may be the specialized knowledge required of teachers who wish to use virtual manipulative for instruction. To use virtual manipulative, teachers must have an understanding of how to use representations for mathematics instruction as well as an understanding of how to structure a mathematics lesson where students use technology. Research has shown that it is a challenge for teachers to transform mathematical ideas into representations (Ball, 1990; Orton, 1988). Teachers must also be comfortable with technology and be prepared for situations where computers may not be reliable or Internet connections are not working properly. These factors may affect teachers and researchers from designing lessons with virtual manipulative.

Studies on computer-based manipulative have produced inconclusive result due to a variety of design and sampling characteristics that may affect student achievement results. A variety of studies in which "computer manipulative programs" were examined for their ability to support student learning in mathematics confirmed positive results in student achievement and attitudes (Char, 1989; Clements & Battista, 1989; Kieran & Hillel, 1990; Thompson, 1992). For example, students' ideas about shapes were more mathematical and precise after using the computer program Logo (Clements & Battista, 1989). Studies where computer manipulative were used in combination with physical manipulative also showed positive gains in increasing students' conceptual understanding Ball, (1988); Terry, (1996). Yet other studies using computer- based attribute blocks Kim, 1993), pegboards and color cubes (Berlin & White, 1986), geometric shapes Nute, (1997), and transformation geometry concepts Pleet, (1990) produced results that indicated no significant improvement in student achievement. Although these results are mixed, the amount of research on high-quality dynamic virtual manipulative is so limited that a judgment about their potential uses in mathematics instruction is entirely speculative. Research, descriptive information, and classroom projects involving virtual manipulative are beginning to

appear in print (Cannon, Heal, & Wellman, 2000: Dorward & Heal, 1999; Drickey, 2000; Moyer, Bolyard, & Spikell, 2002; Nute, 1997; Terry, 1996). In a recent study, kindergarten children created a variety of patterns using virtual pattern blocks, concrete pattern blocks and drawings. Researchers compared the number, type, complexity, and creativity of the patterns the children created during the project (Moyer, Niezgoda, & Stanley, in press). This project found that the children created a greater number of patterns, used more elements in their pattern stems, and exhibited more creative behaviors when they were using the virtual pattern blocks. The virtual manipulative gave second language learners a way to express their thinking and understanding of patterns through the manipulation of the blocks.

Therefore, in this study, manipulatives are defined as objects designed to represent explicitly and concretely Mathematical ideas that are abstract. They have both visual and tactile appeal and can be manipulated by learners through hands-on experiences Moyer, P.S. (2001). Since this study had a focus on fraction work, the researchers specifically used the virtual manipulative that utilized the pictorial image manipulation. This virtual manipulative portrayed the area model of fraction manipulative that simulated the addition of fraction with related denominators. The reason for choosing this virtual manipulative is that it saved time in changing the fraction partitions for different equivalent fractions in order to illustrate and demonstrate the addition of related fractions. Furthermore, pupils can have more chances of creating a number of equivalent fractions for particular fractions in much shorter time compared to the paper cutting and paper folding trial and errors

A study conducted by Kelly Reimer and Patricia S. Moyer has the following results. The use of multiple representations can enhance the development of students' abilities to think flexibly about mathematics topics. The significant results of the conceptual knowledge assessment, where students drew pictorial models and wrote descriptions of their thinking, may point to an important feature of using virtual manipulatives in teaching and learning mathematics – the use of multiple representations in a simultaneous and dynamic visual format. The virtual manipulatives used in this project included visual images of manipulatives, numbers, and words that worked together to respond to students' actions on the computer screen. These visual images, in combination with each other, may have provided important instruction and support while students were interacting with and manipulating the images. This use of dynamic visual models with multiple representations is worthy of further study to determine its impact on students' learning and understanding of mathematical concepts. Virtual manipulatives are an innovative and useful way to enhance mathematics teaching. Because the virtual manipulatives in this study proved to be effective for these students, the classroom teacher has added this teaching tool to her repertoire of instructional resources. This classroom project highlights some of the advantages of using virtual manipulatives for teaching fraction concepts and prompts researchers to examine the effectiveness of dynamic visual models on developing students' flexibility and knowledge of various representational forms.

Utilizing Virtual Manipulatives to Teach Math

In the Philippines setting, there are some Public Elementary and Secondary schools over the country that has not been reached by any means of modern technology teaching tools. Teachers and students in far flung areas still make use of traditional manipulatives since they do not have the opportunity to access technology and media resources. Instead, educators incorporate the usual type of learning strategy which is using traditional tools in all the subject areas. Conversely, there are also some schools that is modernized in terms of the resources used in

teaching. Students in the city areas seems to be more knowledgeable in terms of using the internet and other media resources since they are more expose in the virtual manipulatives (ABS-CBN News, 2013). Philippine Science Academy, one of the top performing schools in the region in the field of Mathematics and Sciences is also up to the trend of using updated facilities and media technologies to improve the quality of teaching and somehow develop and fabricate intellectually advanced students. The aim of the school is for the students to build and generate their personal knowledge based on certain information that is integrated to the media and the Internet ("PSHS.EDU.PH, 2013")

Both the traditional and modernized technologies incorporated in the teaching-learning process produce student learning outcomes. These things provide an excellent resource for constructing challenging thoughts that lead students to deal with their own discernment and modify their thinking. Equally, the physical and virtual manipulatives are primary sources of information or ideas that students work on to formulate individual comprehension in the field of Mathematics.

III. Action Research Questions

This study will focus on the use of virtual manipulative in teaching addition and subtraction of fractions among students at Holy Spirit National High School.Specifically, this study attempted to answer the following questions:

1. What is the performance of the students in fractions before the use of virtual manipulative in terms of:

1.1 Addition

1.2 Subtraction

2. How may the use of virtual manipulative be described in teaching fractions?

3. What is the performance of the students in fractions after the use of virtual manipulative in terms of:

3.1 Addition

3.2 Subtraction

4. Is there a significant difference in the learning outcomes before and after the use of virtual manipulative in terms of the aforementioned variables?

5. What challenges encountered by the students in the use of virtual manipulative?

6. What self- instructional materials (SIM) can be developed in the use of virtual manipulative in teaching addition and subtraction of fractions?

IV. Scope and Limitation of the Study

This study focused on teaching of fraction using virtual manipulative, focusing on addition and subtraction. The study was conducted at Holy Spirit National High School in the Division of Quezon City. The respondents of the study were the Grade 9 students of Holy Spirit National High School who were categorized as mathematically challenged or those who were at risk of failing in Mathematics subjects. This study used experimental and descriptive research method utilizing the researcher-made pre-test and post-test for the respondents.

V. Research Methodology

Research Design

The researcher used the quasi – experimental design because it lacks the key ingredient–random assignment. The researcher used purposive sampling method to choose the respondents, only those who are ease to access which are the researcher's students who were having their hard time in comprehending concepts in Mathematics. More specifically pre-test, treatment, and post-test were used in this study. All the instruments used in this study were validated by the experts.

The project was conducted during a two-week time frame during regular school hours. Students participated in the activities in the project during their regularly scheduled mathematics class sessions.

Sampling Procedure

The study was conducted at Holy Spirit National High School. The researcher chose the said school as the setting of the study because it is where the researcher is rendering her service as a secondary school teacher. The researcher used purposive or no probability sampling, specifically, the researcher used convenience sampling in selecting the respondent. The researcher chose those students who were ease to access, which were the researcher's students who were at risk of failing and those who were left behind and having their hard time coping with the lessons in Mathematics.

Respondents

The researcher utilized a total of 102 students, broken down to twenty (20) students who came from three sections totally to 60 students and 21 students from two sections totally 42 students. These 102 students were from the classes of the researcher at Holy Spirit National High School.

Source of Data

The researcher made used of pre-test and post-test in gathering data. The said instrument is a vital part in determining the students' performance in adding and subtracting of fractions, thus, it measure the effectiveness of the tool used in the study. It consist of thirty (30) items multiple choice test for Addition of Fractions and thirty (30) items for Subtraction of Fractions. It was developed by the researcher and was validated by the experts in the field of education. The contents of every set of test were based on the curriculum guide given by the Department of Education.

Pre-test and post-test were made and used as instrument to determine the effectiveness of the newly designed tool. Same set of pre-tests were administered to the groups then the data were analyzed to check if their knowledge was on the same level. The respondents had undergone virtual manipulative as instructional material. After the treatment was applied to the group, same set of post-test was given to the group to determine if the treatment yielded positive effects on the fraction skills of the students.

The researcher was guided by the related literatures and studies read and by the curriculum guide given by the Department of Education. These were used as a pattern in the formulation of the questions of the study. After constructing the draft of the pre-test and post-test, it was presented to experts for their comments and suggestions.

The pre-test and post-test were tried out to some grade 9 students, for they are not included in the study and they already have knowledge in the topics. Item analysis was be made and those

items that vague were revised. After the pilot exam and item analysis, the tests were checked and validated by the experts.

The tool was utilized by the researcher afterwards at two (2) weeks and was thoroughly documented. After the treatment was applied to the group then the scores were analyzed to check whether the treatment applied was effective.

Data Analysis

After collecting all the data, the researcher arrived at an in-depth analysis and interpretation of the gathered data.

The following statistical tools were employed by the researcher in the study:

Percentage was used to describe the students' performance in addition and subtraction of fractions before and after the use of virtual manipulatives. In this method the percentages are used to determine the frequency counts and percentage distribution of the scores in adding and subtraction of fractions.

$$\% = \frac{f}{n} \text{ x } 100$$

where: % - percentage

f - frequency

n - number of respondents

Paired sample t-test was used to determine whether there is significant difference between the academic performance of the students in addition and subtraction of subtraction of fractions before the use of virtual manipulatives.

$$t = \frac{\Sigma d}{\sqrt{\frac{n\left(\Sigma d^2\right) - \left(\Sigma d\right)^2}{n-1}}}$$

IV. RESULTS

TABLE 1.PERFORMANCE OF THE STUDENTS IN ADDITION OF FRACTIONS BEFORE THE USE OF VIRTUAL MANIPULATIVE

Performance	F	%	Rank
28 - 30 (Excellent)	3	3	5
21 - 27 (Very Satisfactory)	10	10	3
14 - 20 (Satisfactory)	**45**	**44**	**1**
7 - 13 (Fair)	38	37	2
1 - 6 (Poor)	6	6	4
Total	102	100	
	Mean Grade = 12.11 (Fair)		

Data revealed that there were 45 or 44 percent of the students who were rated satisfactory whose grades ranges from 14 – 20.It means that most of the students had difficulties in adding fractions. It was found out that the students had fair performance before the use of virtual

manipulative in addition. Adding fractions was done differently than the usual numbers.

TABLE 2. PERFORMANCE OF THE STUDENTS IN SUBTRACTION OF FRACTIONS BEFORE THE USE OF VIRTUAL MANIPULATIVE

Performance	**F**	**%**	**Rank**
28 - 30 (Excellent)	0	0	5
21 - 27 (Very Satisfactory)	10	10	3
14 - 20 (Satisfactory)	38	37	2
7 - 13 (Fair)	**51**	**50**	**1**
1 - 6 (Poor)	3	3	4
Total	102	100	
	Mean Grade = 11.38 (Fair)		

Data revealed that 51 or 50 percent of the students scored fair with grades 7 – 13. It implied that majority of the respondents were having difficulties in subtraction of fractions.

TABLE 3. PERFORMANCE OF THE STUDENTS IN ADDITION OF FRACTIONS AFTER THE USE OF VIRTUAL MANIPULATIVE

Performance	F	%	Rank
28 - 30 (Excellent)	10	10	4
21 - 27 (Very Satisfactory)	31	30	2
14 - 20 (Satisfactory)	**46**	**45**	**1**
7 - 13 (Fair)	15	15	3
1 - 6 (Poor)	0	0	5
Total	102	100	
	Mean Grade = 17.12 (Satisfactory)		

Findings showed that there were 46 or 45 percent of the students earned a satisfactory grade with scores ranging from 14 – 20. It could be deduced that the students increased their performance after the use of the virtual manipulatives

TABLE 4. PERFORMANCE OF THE STUDENTS IN SUBTRACTION OF FRACTIONS AFTER THE USE OF VIRTUAL MANIPULATIVE

Performance	F	%	Rank
28 - 30 (Excellent)	13	13	3
21 - 27 (Very Satisfactory)	28	27	2
14 - 20 (Satisfactory)	**49**	**48**	**1**
7 - 13 (Fair)	12	12	4
1 - 6 (Poor)	0	0	5
Total	102	100	
	Mean Grade = 16.98 (Satisfactory)		

Data indicated that there were 49 or 48 percent of the students scored a satisfactory grade with grades ranging from 14 – 20. With a grade of mean 16.98, it can be deduced that the students increased their performance after the use of the virtual manipulative.

Data showed that the use of virtual manipulative had a big impact on the performance of students in subtraction of fractions.

TABLE 5.SIGNIFICANT DIFFERENCE IN THE ACADEMIC PERFORMANCE BEFORE AND AFTER THE USE OF VIRTUAL MANIPULATIVE

Topic	Weighted Mean		**t**-value		Decision	Remarks
	Before the use	After the use	Comp	Tab		
Addition	12.11	17.12	1.84	1.671	Reject	Significant
Subtraction	11.38	16.98	2.69	1.671	Reject	Significant

The hypothesis was rejected and concluded that there was a significant difference in the students' academic performance before and after the use of virtual manipulative in addition since the computed **t**-value of 1.84 was greater than the tabular **t**-value of 1.671 using 0.05 level of significance. Data indicated that the use of the virtual manipulative enhanced the students' academic performance.

Since the computed **t**-value of 2.69 was greater than the tabular **t**-value of 1.671 using 0.05 level of significance, the hypothesis was rejected and concluded there was a significant difference between in the students' performance before and after the use of virtual manipulative in subtraction. Findings revealed that the use of the virtual manipulative enhanced the students' academic performance in subtraction.

VII. Summary of Findings

From the data yielded from the instruments, the researcher summarized the following findings:

1. Performance of the students in fractions before the use of virtual manipulative

1.1 Addition. Findings revealed that 51 or 50 percent of the students scored fair with grades 7 – 13. It implied that majority of the respondents were having difficulties in addition of fractions.

1.2 Subtraction. Findings revealed that 51 or 50 percent of the students scored fair with grades 7 – 13. It implied that majority of the respondents were having difficulties in subtraction of fractions.

2. Description on how the Virtual Manipulative was used in teaching fractions

On the first day, a pre -test was given to assess the student's knowledge of fractions. On the second day, the students were taught the concepts in simplifying fractions. On the third day, the students were taught finding the Least Common Multiple of a number. On the fourth day, the researcher started to teach the virtual manipulatives using software on a computer until day eight. Students interacted with the virtual manipulatives in the computer lab on five consecutive days. There were 35 computers available in the computer lab, and a large screen where the teacher could display examples for the whole class to view. Student worked independently at their own computers during the virtual manipulative activities. There were series of questions about adding and subtracting of fractions. The sequence was based on its difficulty level. The student-computer ratio was 1:1.

On the ninth day, students were given paper based examinations similar to the pre-test administered to them before the start of the study.

3. Performance of the students in fractions after the use of virtual manipulative

3.1 Addition. Findings showed that there were 46 or 45 percent of the students earned a satisfactory grade with scores ranging from 14 – 20. It could be deduced that the students increased their performance after the use of the virtual manipulatives.

3.2 Subtraction. Findings revealed that there were 49 or 48 percent of the students scored a satisfactory grade with grades ranging from 14 – 20. With a grade of mean 16.98, it could be deduced that the students increased their performance after the use of the virtual manipulative. Data showed that the use of virtual manipulative has a big impact on the performance of students in subtraction of fractions.

4. Significant difference in the learning outcomes before and after the use of virtual manipulative

Data below summarized the significant difference in the academic performance before and after the use of virtual manipulative.

The hypothesis was rejected and concluded that there was a significant difference in the students' academic performance before and after the use of virtual manipulative in addition since the computed **t**-value of 1.84 was greater than the tabular **t**-value of 1.671.

Since the computed **t**-value of 2.69 was greater than the tabular **t**-value of 1.671, the hypothesis was rejected and concluded that there was a significant difference between in the students' performance before and after the use of virtual manipulative in subtraction.

5. Challenges encountered by the students in the use of virtual manipulative

Without adequate material resources in ICT delivery of instruction might suffer.Another challenge encountered by the teachers was lack of time in preparing the lecture for presentation using virtual manipulative. .It was observed that the school did not had internet connections per faculty room. If they want to use internet, they have to purchase data packages on their own or go to the office to use the wifi since wifi connection was not available around the school. There were cases that there were computer units or laptops were being not responsive in the middle of the presentation, USB connection not working or even some remote control missing.

The researcher had observed that older teachers were not that equipped with ICT skills so that they preferred to use visual aids or old way of teaching.

6. Development of Self- instructional materials (SIM) in the use of virtual manipulative in teaching addition and subtraction of fractions

Based from the results of the study, self- instructional materials (SIM) was developed in the use of virtual manipulative in teaching addition and subtraction of fractions.

VIII. Plans for Dissemination and Advocacy

Based from the findings and conclusions of the study, the following recommendations were offered:

For Students

Students maybe encouraged to use virtual manipulatives in learning mathematics.

For Teachers

Teachers may have to review the procedure on how the Virtual Manipulative which can be used in teaching fractions for its effective use.

For Curriculum Planners

Curriculum Planners have to develop more instructional materials using virtual manipulatives as it enhanced students' performance.

For School Principals and Administrators

School principals need to motivate not only mathematics teachers in using virtual manipulative for classroom instruction in all disciplines.

School administrators may develop strategies, find solutions/ remedies to address the challenges encountered by the students in the use of virtual manipulative.

For Future Researchers

Future researchers may consider the use of the developed self- instructional materials (SIM) in the use of virtual manipulative in teaching fractions.

XI. REFERENCES

ABS-CBN NEWS(2013).*Integrating manipulatives in schools: 21st century learning*. Retrieved from https://ABS-CBNNEWS.COM

Ball, S. (1988). *Concrete materials and teaching fractions.School Science and Mathematics*, 88, 470- 475.

Behr, M. J., Wachsmuth, I., Post, T. R., & Lesh, R. (1984).*Order and equivalence of rationa*l *numbers: A clinical teaching experiment. Journal for Research in Mathematics Education*, 15(5), 323 – 341.

Moyer, P. S. (2001). Are we having fun yet? How teachers use manipulatives toteach mathematics. Educational Studies in Mathematics: An International Journal, 47(2), 175–197.

Moyer, P. S., Niezgoda, D., & Stanley, J. (2005). *Young children's use of virtual manipulatives and other forms of mathematical representations.* In W. J. Masalaski & P. C. Elliott (Eds.), Technology-supported mathematics learning environments (pp. 17–34). Reston, VA: National Council of Teachers of Mathematics