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Original Article (Pages: 13599-13607)

Evaluating the Effectiveness of Using Merrill Component Display Theory in Performance and Retention of the Concept of Fraction in Kids Grade Elementary Mathematics

Maryam Manuchehri[1], *Mohammad Hassan Behzadi[2], Ahmad Shahverani Semnani[1], Mohsen Rostamy[1]

[1]Department of Mathematics, Science and Research Branch, Islamic Azad University, Tehran, Iran.

[2]Department of Statistics, Science and Research Branch, Islamic Azad University, Tehran, Iran.

Abstract

Background

The concept of fraction is one of the most difficult concepts of math in all levels of education. We aimed to investigate the effect of Merrill's component display theory in the learning of students in math.

Materials and Methods: In this case-control study, the number of students under investigation was 183 boys where 31 students were randomly selected as experimental group and 30 as control group. The concept of teaching was designed based on the teaching design pattern of Merrill's Component Display Theory and based on which the students in experimental group was taught for 10 sessions of 45 minutes; control group also received the traditional teaching. After two months, students were post-tested for their performance by a 10-question exam taken from teacher's guidebook. Then, after three more weeks, they were again post-tested to ascertin their retention of the topic. Data were analyzed using SPSS software version 16.0

Results: The T-test results showed that the mean of students in experimental group increased about four grades and from 13.9 reached to the significant number of 18 for the performance post-test with the standard deviation of 0.63. In retention, the mean of students changed from 15.4 to 15 which is not a lot. It also means that there was no significant difference between mean scores of retention of Merrill' group and the scores of post-test Merrill's group. It means that education materials used Merrill's design have been positively effective.

Conclusion

Considering the findings, it can be stated that the Merrill's component display theory has been effective in both performance and the retention of the students.

Key Words: Component display theory, Evaluation process, Fraction, Retention, Kids.

*Please cite this article as: Manuchehri M, Behzadi MH, Shahverani Semnani A, Rostamy M. Evaluating the Effectiveness of Using Merrill Component Display Theory in Performance and Retention of the Concept of Fraction in Kids Grade Elementary Mathematics. Int J Pediatr 2021; 9(5): 13599-607. DOI: **10.22038/IJP.2020.52220.4149**

Corresponding Author:

Dr. Mohammad Hassan Behzadi, Department of Statistics, Science and Research Branch, Islamic Azad University, Tehran, Iran.

Email: Behzadi@srbiau.ac.ir

Received date: Dec.05, 2020; Accepted date: Mar 22, 2021

1- INTRODUCTION

Sound knowledge of students from mathematical concepts are very important for developing mathematical knowledge of students while dealing with the mathematics-related challenges (1). Fraction is one of the most important but difficult issues in the students' curriculum in elementary and secondary school all over the world (2). Fractions are the basics of learning rational numbers and is the key of success in learning further related issues in secondary schools (3). Many researchers have done some studies to ascertain students' feelings in learning fraction. They have found that the topic of fraction in hard both to learn and to teach (4), for example, in a study by the US National Assessment of educational progress (NAEP, 2007), it was reported that 60% of students in fourth level cannot understand that 1/4 is more than 1/5 and even 50% of eighth level students cannot select the largest fraction among three fractions; many of the teachers also get into difficulty teaching the fractions (5).

It seems that the traditional methods of teaching fraction are neither accurate nor effective; and will not satisfy both learners and academic system in twenty first century; hence, new methods of teaching should be investigated to manage this gap. The traditional methods of teaching fraction have a weakness in providing a good concept of fraction and students are not demanded to understand concepts beyond part-whole concept, which is the basis for teaching fraction; therefore, they cannot imagine further and this will get them into difficulty for later mathematical topics (2). Undeniably, instructional design (ID) has been regarded as a process that is systematic and facilitative in teaching (6-8). One of these IDs is Component Design Theory (CDT), which was introduced by David Merrill and was considered a complex, thorough, interconnected rule driven set of concepts and approaches toward design of instruction. The focus of this theory is on learners and it is considered a learner-driven method and looks at the cognitive realm of teaching. The theory works to differentiate content from instructional strategy to provide a process through which content can be injected to appropriate strategies aligned with special content types and performances (9). Emino EV Horstt used Component display theory for teaching on 95 Japanese students. The acquired results showed an outstanding outcome in students' educational level and had a positive effect on the students' self-confidence (10). Moreover, it had positive influence on the students' viewpoint about their own learning. Merrill (2007) doing a research on the Component display theory pattern came to the conclusion that teachers should develop the courage to shift from more traditional patterns and move to more modern ones and by employing their own creativity move towards the learning patterns that develop growth opportunity and better the quality of education. He believed when cognitive structure involves learning, the learning improves He also stated that education should not merely be transferring the information using technology, but it should be interesting, efficient and effective (9).

Siegler et al. (2012) did a research in England and the Unites States and found that students' performance in fraction in fifth and sixth grade is connected to their performance in algebra and math in higher levels and the results emphasized on the importance of learning fraction in fifth and sixth grade (11). A consideration on Merrill's educational principle shows that it involves the most important elements of a qualified education. National Mathematical Advisory platoon stated that understanding the concept of fraction and solving fractional problems is one of the main goals of kids' learning (3). Torbeyns et al. (2015) conducted a research in the

United States, China and Belgium. Taking in to account that the knowledge of teacher in these three countries are not the same and the educational tools are not equal, it can be concluded that there is a relationship between understanding the fraction and improvement in Math (12). Oka (2017) conducted a research with the aim of producing educational materials in an effective interactional environment that can improve the learning results. He also used Component Display Theory (CDT) for developing educational design and compared the results of learning before and after using interactional educational material employing T-test. The results of learning before and after using interactional educational material were different. He concluded that designing with the help of CDT can improve the results of students' learning (13).

Moreover, Nguyen et al. (2017), conducted a research on the identifying the concept of fraction by the students in Vietnam and came to the conclusion that students of level four and five in elementary school learn the concept of fraction, but understanding the application of that for them is difficult and that students have many mistakes solving them and they do not get the concept of fraction in their learning (14). Considering the results of research in this article, the researchers found that there was no record on the efficiency of CDT on the function and the retention of math, fraction concept, for students of sixth level in Iran; therefore, this research can be innovative for such a case. We aimed to investigate the effect of Merrill's component display theory in the learning of students in math.

2- MATERIALS AND METHODS

2-1. Study design and population

This case control study was designed to be experimental regarding the aim of research. The overall population was 180 boys students of sixth grade in 6 classes at Motsafa Khomeini Elementary public school located in section 18 of Tehran, Iran. Among them, 61 students were selected to participate in the study. The method of sampling was stratified random sampling where two groups (classes) including experimental group (31 boys), and control group (30 boys) were chosen.

2-2. Methods

To do this research, first, the population was pre-tested and based on which 61 students who were in the same level of knowledge were selected. They were categorized to two experimental (31 students), and control group (30 students). Then the experimental group was taught the fraction based on Merrill's Component Display Theory.

2-3. Measuring tools

The tools used in this study were two researcher-modified ten-item questionnaires, which were taken from teachers' guide published by ministery of education and pedagogy. The pre-test questionaire had ten items which consiered knowledge and was used to evaluate the input behavior of students. Post-test questionaire was also ten items among which two focused on knowledge, six in the realm of application and two items in the realm of concept. The writers of the book checked the validity of both questionaires and the reliability of them was measured by Alpha Cronbach, which were 0.78 for pretest and 0.81 for post test. The next tool was ten lesson designs, which was provided by the researcher. Moreover, softwares such as flash player and motion graphics were used. Further was a series of colorful cards designed for better learning of the students.

2-4. Intervention

The intervention used in this research was ten 45-minute sessions as the teaching of fraction for improving the performance and retention of the students. A teacher

whose level of education was M.A. in Teaching Mathematics performed this intervention. One of the interventions in this study was as follows:

2-4-1.The title of the lesson: Fraction

Introducing the topic: Lessons should be started with real things; a part from a piece of cookie is taken, in this case, the teacher says a fraction of that cookie has been taken; but as it is not clear how much, nothing can be written for that fraction. Now, the teacher should take a piece of bread or a paper and divide it into equal parts. What fraction of the whole is each part of that piece of bread or paper? The teacher should take an apple and divide it into eight equal parts; what fraction of the whole is each part? In these examples because objects are divided into almost equal parts, the teacher can write a fraction for them.

2-4-2.The title of the lesson: Activity

Activities to better understanding the concept by students

Activity 1 (dividing approximately): At first, students should choose a paper band or a piece of thread as long as a favorite circle. Then by folding the paper or thread into intended number, putting it on circumference of the circle and after that marking, they divide the circle into equal parts. Next, the students explain the way that they divided the equal parts. Explaining increases the verbal communication among students and enhances their interpretation skill. Each student should perform manipulative, graphic and verbal activities to reach the intended level.

Activity 2 (dividing into equal sizes) the teacher should classify the students of the class, each group is given a number of equal rectangular papers (about 10). Then, members of the group are asked to think firstly about how to divide these papers among themselves individually. Next, they are asked to cooperatively present and explain their method of dividing. Students should try to divide each rectangle differently from their pier learners. After finishing the determined time, groups should stick the divided rectangles on the board. After that, students cooperatively omit the shapes, which have similar divisions in a way that no attached shapes are similar on the board. Now, groups should discuss and explain their method of dividing.

Designer's note: Considering the steps of designing by Merrill's method, presentation sample was in activity 1, secondary presentation form using getting attention cooperatively was in activity 2 and the divergent rule was observed.

Mix Number: The teacher starts with an explanation and reminding the concept of fraction from the parts to the whole. It is clear that the fraction of 5/7 means five parts out of seven equal ones. Now the teacher should ask students what is the meaning of 9/7? Teacher should pose the question in the class and discuss it. The ideas of the students should be taken into account carefully and reacted accordingly. Considering the point that this concept has been taught in the previous years, the teacher should start the lesson with some questions from the students. Fraction and mix number are two different representations of one number. To write a number in mix number representation, students should understand and determine the number of complete units. Students should come to the idea that fraction and mix number are two representations of one concept; therefore, moving from fraction to mix number and vice versa is of paramount importance.

2-4-3. Activity

Suggested activities to better understanding of the concept by students

Activity 1 (better understanding between measurement and mix number): Students should be asked to measure the length of a pen or any other objects which are appropriate to teach this concept using suitable measurement tools (meter or ruler), and the acquired number should be shown with the unit of centimeter and millimeter (or meter and centimeter) in a fraction form, the number of complete unit and a fraction of the complete unit and mix number. Moreover, with the help of **Figure.1** and using 10-member groups (a complete unit), and one-member group, they should show the number related to the figure in a mix number representation. Through this activity, students learn that they can also choose a complete unit in a two-dimensional continuous shape. It should be taken into account that the method of choosing a complete unit and the process of their correct interpretation refers to themselves.

Activity 2 (a better understanding for choosing unit): İn case students have problems choosing unit, they can follow the proceeding steps;

1) A unit should be chosen that has been made from some continuous shapes.

2) Some of these units are drawn on a cardboard and cut with the help of students.

3) Students are provided with the units (each group receives equal units).

4) Groups are asked to put some of the cardboards near each other and read the acquired fraction.

5) According to the unit, a fraction should be selected and then groups are required to show them with their own units.

6) Now, considering the unit, the teacher should choose a fraction that is of a complete unit and a part of composed unit and groups are asked to show them by their own units.

7) Students are allowed to show the intended mix number with coloring and cutting a part of the unit and putting them beside each other.

The teacher should hold a competition by grouping the students; at the beginning, the first group should state a fraction and the second group show it on the number axis, then the second group state a fraction and the first group show it on the number axis. (second representation form-getting attention)

2-4-5. Determining the homework: At the end of teaching, the activities in the textbook were chosen as homework.

2-5. Ethical consideration

In order to observe the ethical issues in this research, the general organization of education and pedagogy was consulted and the researcherwas permitted to do the research on the students on section 18 of Tehran. Moreover, their parents were informed for this research.

2-6. Inclusion and exclusion criteria

The researcher tried to focus on normal students and students with learning disabilities were excluded; moreover, those elite students also were not selected so as not to deviate the results of the study.

2-7. Data Analyses

In order to analyze the data, SPSS software version 16.0 was used and the collected data entered into the program for different kinds of T-test. The first one was checking the normality of pre-test group, then the normality of post-test and the normality of retention test. Moreover, Two independent T-tests were done; the first one refers to the significance of learning from pre-test and post-test and the second one the T-test between retention test which was presented to students after three weeks following the posttest and the post-test

itself. To score students' test, a range of 0 to twenty was chosen, and their answers to each question, which was accurate, were added together. The highest score of pretest for control group and the experimental one was 20; and the lowest score was 4 and 2, respectively. Moreover, the highest score for posttest in control group was 20 and for experimental group was 20; next the lowest score for control group in post-test was 5 and for experimental group 15. In addition, the highest score for retention control group was 16 and for experimental group was 19; the lowest score for retention control group was 2 and in experimental group 11.

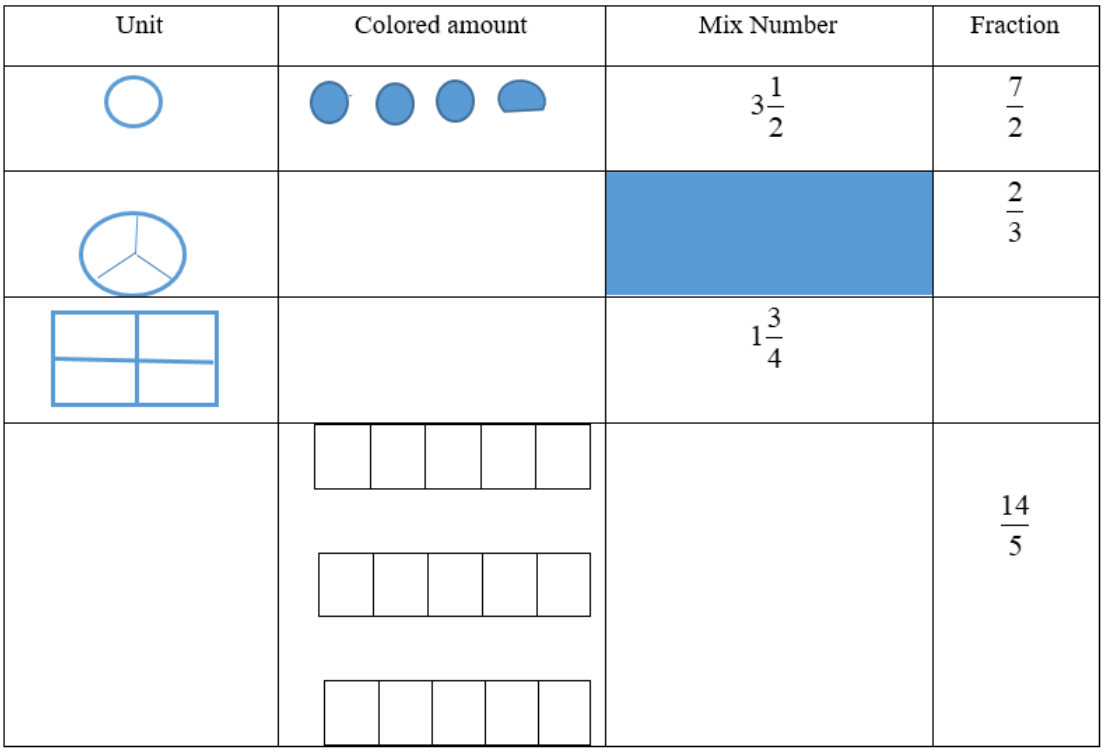

Fig.1: Students were asked to show fraction and mix number using various shapes. (Questioning from the example). Students were also demanded to determine fractions from a group of numbers (observing matching rule).

3- RESULT

As two groups participated in this research where one was the experimental group including 31 and the second was the control group including 30 students, in order to consider the question whether teaching based on the Merrill's teaching design pattern (the component display theory) wass effective in performance and retention of the topic for sixth level elementary school students or not. Parametric independent sample T-test was used. Descriptive information for children, including gender and age is presented in **Table.1**.

Table-1: Frequency distribution of the studied sample by demographic variables.

Variables	Variable levels	Frequency
Gender	Boy	61
Age	12 years	61

But the validity of this test is based on the normality presupposition of observations. Therefore, the normality test, i.e. Kolmogorov-Smirnov test was used and the normality was confirmed. **Table.2** shows the Independent T-test considering that students were not significantly different in pre-test.

Table-2: Independent Samples Test.

Variable		Levene's test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t-test	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI	
									Lower	Upper
VAR	Equal variances assumed	12.42	0.001	-0.51	59	0.612	-0.63	1.24	-3.11	1.85
	Equal variances not assumed			-0.49	45.4	0.621	-0.63	1.27	-3.19	1.92

df: Degree of freedom, VAR: Value at risk, CI: Confidence interval.

Due to the point that based on the Levine's exam result ($P<0.05$), the presumption of equality of variances are supported, the second row of the **Table.2** was used. In this row, considering –P the calculated measure ($P>0.05$). It means that the students' mean scores in two groups of experimental and control group are not significantly different. Moreover, they are equal based on the educational level. Then, the difference between the mean scores of performance posttest of experimental and control group is regarded. In order to do this test for this concept, the presumption exam is considered. The mean scores of students in two groups of control and experimental are equal after the formal teaching. Alternative hypothesis: the mean scores of students in two groups of control and experimental are not equal after the formal teaching. The results are shown in the **Table.3**.

Table-3: Independent Samples Test.

Variable		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t-test	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI	
									Lower	Upper
VAR	Equal variances assumed	31.27	0.000	3.12	59	0.03	3.16	1.01	1.13	5.18
	Equal variances not assumed			3.07	33.76	0.04	3.16	1.02	1.07	5.24

df: Degree of freedom, VAR: Value at risk, CI: Confidence interval.

According to the significance of **Table.3** stating that, $P < 0.05$ means the mean score of students in two groups of control and experimental after teaching is not equal; and according to positive trend of highest and lowest part, the mean score of the two population is bigger than zero. Moreover, the mean score of Merrill in post-test is bigger than control group. **Table.3** also reveals that there is no significant difference between mean scores of retention of Merrill' group and the scores of post-test Merrill's group. This shows that education materials used Merrill's design have been positively effective.

4- DISCUSSION

Professional teachers are always trying to make an interaction between the curriculum and students' needs and this interaction is viable due to effective educational design. It is inevitable for modern educational systems in contrast with the ancient ones to face with a great realm of topics. It is sometimes impossible to find solutions to these questions with the approaches, tools, and old methods. As NCTM has insisted students who memorize the rules and the mathematical approaches without having any exact understanding do not employ these rules and approaches in solving mathematical problems because they often have forgotten them, or do not remember them exactly. Through this method, learning is completely unstable and forgettable.

In contrast, students who have provided themselves with a deep conceptual understanding of mathematical concepts employ all mathematical approaches in solving the problems and their learning are more lasting. Using Merrill's educational design, a teacher can somehow help students to learn the concept of fraction. Researchers in a study concluded that understanding the concept of fraction can have predictive feature in learning the next mathematical topics such as algebra (15).

Researchers in a study concluded that understanding the concept of fraction can have predictive feature in learning the next mathematical topics such as algebra. Modern educational technology can be very influential for students' gaining higher results for learning fraction (16). Shin and Lee (2017) believed that the differences in method of presenting mathematical topics related to fractions can be effective in students' learning (17). It is believed that cognitive competence affect learning mathematical concepts such as fraction. It is also stated that careful attention and focus on mathematics instruction help students achieve a better result in learning the relevant knowledge (18, 19).

4-1. Limitations of the study

There were some limitations in doing this research. First, students' intelligence, creativity, and the Math knowledge could not be controlled. Second, the concepts of fraction had not been taught to students and correctly in previous years. Third, the teaching was limited to schoolbook topics.

5- CONCLUSION

This research aims at the efficiency of Merrill's educational design (Component Display Theory) on the performance and retention of the students of the sixth level at elementary school in Math, the concept of fraction. Based on the findings of this research, there was no significant positive effect on the performance of the students in learning the concept of fraction, but it was effective on their retention after three weeks. Considering the point that Merrill's theory was a cognitive all cognitive theories focus on psychological processes of the learners and take a minor look on environmental factors for students' learning, it concluded that this teaching has led to students' retention. The cognitive theory was based on the point that how learners process and acquire information and then apply it. The cognitive learning theory emphasizes on the identifying the structures, processes and the cognitive presentation that facilitate teaching and learning.

6- ACKNOWLEDGEMENTS

Acknowledgements of people, grants, funds, etc. should be placed in a separate section before the References. If the work has been presented in a conference or scholarly meeting, it should be mentioned here. The approved thesis code is 100099.

7- CONFLICT OF INTEREST

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the author(s).

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