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An Investigation of the Use of Paper Folding Manipulative Material on Learners' Performance in Fractions in Grade 9

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ABSTRACT

The aim of this study was to investigate the use of Paper folding on grade 9 learners' performance in fractions. Pre-test, Post-test, and Control group quasi-experimental design was used to collect data. The study group was made up of 250 grade 9 learners' which encompassed 125 learners in the experimental group and 125 learners' in the control group. Multiple sampling techniques of systematic simple random, convenience, purposive and stratified sampling methods were adopted for the study. The data collected were analysed using Analysis of Covariance (ANCOVA) to find the Mean, Standard Deviation and Sample T-test. The mean and standard deviation were used to compare the pre-test and post-test between the Experimental group and Control group. The analysed results of the means, standard deviations and T-tests were used to reject the null hypotheses. The analysed results of Paper folding showed that the pre-test (mean = 8.372, SD=1.770), post-test (mean = 11,792, SD=4.256), t=12,024 p< 0.05. The hypotheses were tested at 0.05 level of significance.

Keywords: *Educators, Fractions, Grade 9, Learners', Manipulative material,* Paper *folding,*

I. INTRODUCTION

Fractions are essential aspect of mathematics that formed the bedrock of every learner's success in mathematics as postulated by the National Mathematics Advisory Panel (NMAP, 2008). Lortie-Forgues, Tian and Siegler (2015) argued that, the prominence of fractions and decimal calculation for academic accomplishment was not restricted to mathematics courses only. Rational number arithmetic was also ever-present in physics, chemistry, engineering, psychology, sociology, biology, economics, and other spheres of studies.

Gould, Outhred, and Mitchelmore (2006), asserted that educators, learners and academics have typically described fractions learning as a difficult aspect of mathematics syllabus. Researchers underscored the fact that learners found it problematic to comprehend the idea of "a part as a whole" relationship in mathematics. Studies showed that fractions were very challenging topics educators and learners are confronted with on daily basis (Tobias, 2013). Most educators have little knowledge of fractions necessary for classroom instructions (Harvey, 2012). The Centre for Development and Enterprise (CDE, 2011), indicated that South African learners' poor performance in national assessments in mathematics could be linked to teacher's poor content knowledge and lacked of innovative methods of fractions instructions. In support, Davis (2016) concurred that there existed a gap between the way learners experienced fractions in the out-of-school and in-school settings. The school mathematics curriculum had not made the concepts fractions relevant to learners in their everyday life activities. Sharing which formed the basis of the introduction of fractions as division in schools, was also widely practiced in the out of school environment. It was evident that learners lacked the knowledge of linking the concept of fractions at home to the concept of fractions at school due to the physical properties that were used in the instructions (Davis, 2016).

In 2013, the National Council of Supervisors of Mathematics (NCSM) issued a position statement on the use of manipulative concrete materials in classroom teaching to develop learners' accomplishment in mathematics. "In order to develop every student's mathematical proficiency, leaders and educators must systematically integrate the use of concrete and virtual manipulative into classroom instruction at all grade levels" (NCSM, 2013). In a similar vein, the West African Examinations Council (WAEC, 2007) Chief Examiners report recommended the use of hands-on and physical illustration in teaching abstract ideas to enhance understanding and to awaken and facilitate learners' interest in fractions. Van de Walle, Karp, and Bay (2013), described a manipulative concrete material as a mathematical tool or, any item, image, or drawing that embodied an idea or onto which the connection for that concept cold be enacted. In a similar view, manipulative concrete materials were physical objects that could be utilized to demonstrate and undraped mathematical ideas such as fractions.

Fractions played a very important role in our technological world because our daily lives heavily relayed on the ability to compute fractions correctly, competently, and insightfully (Pienaar, 2014). Also, fractions formed the fundamental blocks for future success in mathematics (National Mathematics Advisory Panel (NMAP), 2008).

II. LITERATURE REVIEW

Paper manipulative concrete materials were mathematical tools made from papers mostly hard cards. They were made in different shapes, size and colour. They included; paper folding, puzzles, hundred charts etc. (Special connection, 2009).

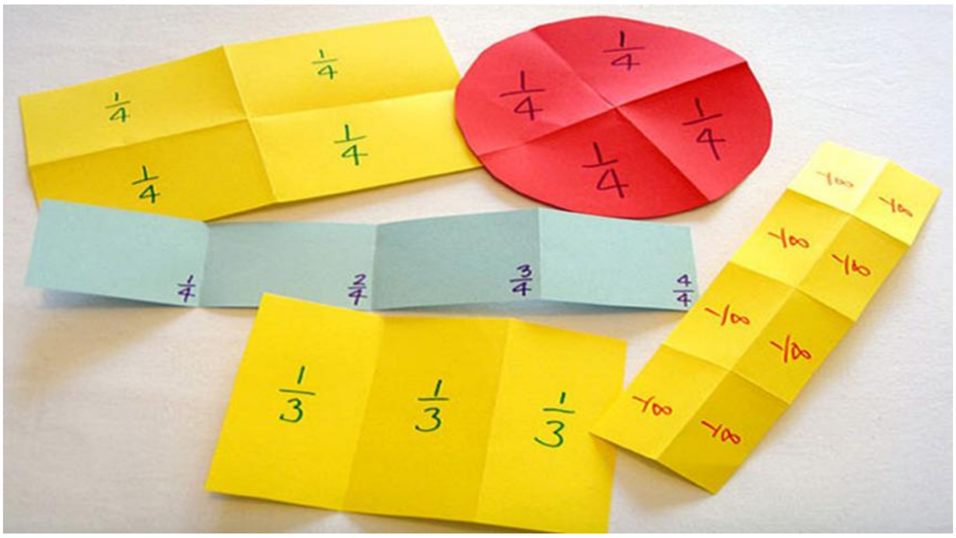

Fig1: Paper manipulative concrete materials. (Source: Ervin 2017).

Fraction could be modelled using a piece of paper as the physical object to demonstrate area as fraction multiplication using paper folding. This demonstration was generated by folding a piece of paper into equal sizes in relation to the problem under study (Ervin, 2017:265). Paper folding played a very vital role in learners' comprehension of division in fractions (Johanning & Mamer, 2014). Through paper folding modelling, learners were able to visualised problems in figurative form through lens that highlighted the scale of the dividend and divisor. This enabled learners to make better judgement of their solutions (Ervin, 2017:265). Frasher (2013), asserted that learners of all categories of age group could benefit from the use of concrete manipulative materials in the instruction of mathematical concepts. However, Ross (2008) attested to the fact that educators who are not in tuned with the applications of concrete manipulative materials especially Paper folding are most liable of limiting the success of teaching, classroom organisation, and improving learners mathematical achievements in fractions.

Figure 2 illustrated Paper folding approach in solving fraction division problem. For example; solve $3/5 \div 1/3$

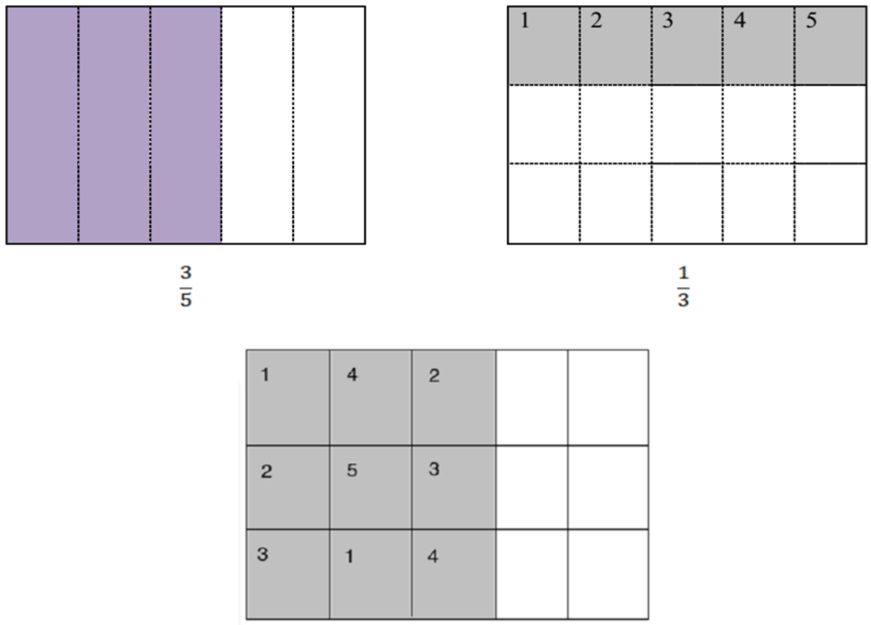

Fig. 2: Paper folding showing division of fractions (Source: Ervin 2017).

How many $1/3$ fits into $3/5$? Five grey blocks made up $1/3$ of the whole unit. One whole set of these grey blocks and four out of five of a second set of grey blocks would fit into the purple region if we considered the purple region to contain nine grey blocks. Thus $3/5 \div 1/3 = 14/5$ (Ervin, 2017).

III. Theoretical framework

In this study the researcher adopted Cognitive Development Theory and Constructivism Theory for the study.

1. Cognitive development theory:

Cognitive development theory was the process of receiving information through the senses as well as the clarification of the information (Donald et. al., 2010:58; Robinson & Lomofsky, 2010:34). De Witt (2011) defined Cognitive development as the ability to make intellectual judgement through the process of involving all the mental faculties to learn, pay attention, recall, verbalize, make meaningful discernment, innovation and ingenuity. In a similar vein, researchers argued that cognitive development was the ability of modifying mental capabilities or skills, such as; language, learning, thinking, attention, creativity, and reasoning (Lerner & Johns, 2009:153; Papalia, Wendkosolds & Duskin 2008:10). The development of intellectual abilities and skills were very much important in solving problems, making effective decisions and transforming passive, dependent learners into dynamic enthusiastic learners who could apply their cognitive ability into an extensive range of real life situation (Donald et al., 2010:58; Eggen & Kauchak, 2010:30; Benjamin, 2009; Lerner & Johns, 2009:164).

2. Constructivist theory:

Constructivist theory dealt with knowledge acquisition through which individuals gained information and comprehended the information from their personal experienced. In constructivism, entities developed independent meanings of their experienced and meanings directed towards specific items. These items were diverse and multifaceted, leading the investigator to look for varied views rather than limiting understanding into a few categories or thoughts (Creswell, 2013:8). The significant aspect of this theory was the decomposition of each mathematical concept into developmental phase in line with Piagetian theory of intellectual development based on observation and interviews with students as they tried to learn a concept (Mathforum, 2015). Robson, (2006:13-14); Fraser, (2013); Troutman and Lichtenberg, (2003), asserted that the constructivist technique of tuition identified the significance of the learner in the learning process and allowed the learners to discover their own knowledge through the self-discovery method.

IV. METHODOLOGY

Multiple sampling techniques of convenience, purposive and stratified sampling methods were used to select 40 public schools from Chris Hani West education district. A sample of 250 participants was selected from the schools chosen for the study. A systematic simple random method was used to group 250 participants into Experimental group (125) and Control group (125). Pre-test and Post-test were used to collect data from the Control group and Experimental group.

The null hypothesis was tested at 0.05 level of significant. The null hypotheses were stated as followed:

H_{01}: There is no difference between the results of the Pre-test and Post-test of the Control group and

Experimental group in Paper folding.

H_{02}: There is no significance influence of Paper folding on learners' performance in fractions in grade

Nine.

V. Data Analysis

H_{01}: There is no difference between the results of the Pre-test and Post-test of the Control group and

Experimental group in Paper folding.

Table 1: Findings of Paper Folding Manipulative Tool Data Set

Group	N	Trial	Mean	Standard deviation	Min	Max
Control	125	Pre-test	8.192	1.735	0	14
	125	Post-test	7.872	1.465	5	11
Experiment	125	Pre-test	8.552	1.794	2	11
	125	Post-test	15.712	1.804	6	19

Source: Field work (February, 2019).

Table 1, illustrated the Mean scores and Standard deviation of the Paper folding manipulative tool in the Pre-test and Post-test of both Experimental group and Control group. The Pre-test mean scores and standard deviation of Experimental group (mean $\bar{X}$ = 8.552, SD=1.794) and Control group (mean $\bar{X}$ = 8.192, SD=1.735) respectively. The Post-test mean scores and standard deviation showed Experimental group (mean = 15.712, SD= 1.804) and Control group (mean =7.872, SD=1.465) respectively. The results showed that there is difference between the results of the Experimental group and Control group in the pre-test and post-test ($P < 0.05$). Hypothesis (H_{01}) was therefore rejected.

H_{02}: There is no significance influence of Paper folding on grade nine learners' performance in fractions.

Table 2: Analysed results of Paper folding

Pair	Mean	Std. Deviation	Std. Error Mean
Paper folding manipulative Post-test	11.792	4.256	.269
Pre-test	8.372	1.770	.112

	Paired Differences					t	df	Sig. (2-tailed)
Pair	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Paper folding P ost-test - Pre-test	3.420	4.426	.280	2.868	3.971	12.219	249	.000

Source: Field work (February, 2019).

To prove that there was a significant relationship between Paper folding and learners' performance in fractions, the pre-test and post-test mean and standard deviations scores were compared using sample paired t-test. Table 2, showed the scores of mean and standard deviation of Paper folding in the pre-test (mean $\bar{X}$=8.372, SD=1.770) and post-test (mean $\bar{X}$=11.792, SD=4.256) respectively. This indicated that the experimental group gained higher scores in the post-test. The result of the sample t-test (t=12,219; $p < 0.05$). This indicated that there was a significant relationship between Paper folding and grade nine learners performance in fractions. Thus the null hypothesis (H_{02}) was rejected.

VI. CONCLUSIONS

The study has revealed that Paper folding manipulative material has a positive effect on learners' performance in fractions. Johanning and Mamer, (2014) asserted that Paper folding played a very vital role in learners' comprehension of division in fractions Recommendations. In support, Ervin, (2017) opined that through paper folding modelling learners were able to visualise problems in figurative form through lens that highlighted the scale of the dividend and divisor and were able to make better judgement whether their solutions were viable or not. Ervin (2017:), emphasised that it was very necessary for pre-service educators to be able to sketch and fold area models since paper folding exposed pupils to physical experience.

The following recommendations were made from the study:

1. Learners' ought to use Paper folding manipulative concrete materials frequently in their mathematical lessons so that they would be up-to-date with it and also increased their comprehension in fractions.
2. Mathematics educators ought to ensure that they incorporate Paper folding manipulative concrete materials in the instructions of fractions in mathematics.
3. School principals ought to ensure that mathematics educators integrate Paper folding manipulative concrete materials in the instructions of mathematics in their schools.
4. It should be obligatory for the Department of Education to ensure that every school is well resourced with manipulative concrete materials to enhance the mathematical proficiency of the learners'.
5. The government ought to enact policies that would strictly involve the use of Paper folding manipulative concrete materials in the instructions of mathematics at all grade level.

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