



Effect of Area Model on Multi-Digit Multiplication Performance of Primary Six Pupils

¹Aishatu Abdulkarim, ²Anas Husaini Toro, ³Muhammad Nasiru Murtala, ⁴Nazif Umar Dogo

¹Gombe State University, Gombe.

^{2,3,4}Abubakar Tafawa Balewa University Bauchi

ABSTRACT

The study examines the effect of the Area model on primary six-pupil performance in multi-digit multiplication in the Bauchi State of Nigeria. The study used one group pre-test post-test experimental design. Two research questions and two null hypotheses were formulated to guide the study. The population is comprised of 102 primary six pupils of Abubakar Tafawa Balewa University Staff School. Extreme case purposive sampling technique was used to select two groups of pupils, comprising of 15 high performing and 15 low performing primary six pupils based on their mathematics scores in the last promotional examination. An intervention lesson was conducted with the 30 pupils for the period of two weeks, they were taught multi-digit multiplication using the Area model. The instrument used for data collection was Multiplication Problem Test (MUPT). The MUPT was administered before and after the intervention. Mean and standard deviation was used in analyzing the research questions while paired samples t-test was employed for testing the hypotheses at 0.05 level of significance. The findings among others revealed that: Significant difference existed between the pre-test and the post-test result; it was also discovered that there was no significant difference between the performance of males and females when taught multi-digit multiplication problems with the use of the Area model. Based on the findings it was recommended among others that primary-six mathematics teachers should use the Area model when teaching multi-digit multiplication.

ARTICLE INFO

Article History

Received: July, 2020

Received in revised form: October, 2021

Accepted: November, 2021

Published online: November, 2021

KEYWORDS

Area model, performance, multi-digit multiplication, mathematics.

INTRODUCTION

Multiplication has been regarded as a key concept in students' elementary and advanced mathematics (Vanluydt, Wijns, Torbeyns, & Van Dooren, 2021). Moreover, in stressing the importance of multiplication Lesh, Post, and Behr (1988) described it as both the capstone of primary school mathematics and cornerstone for later mathematical understanding. However, previous research indicated that general performance of pupils in primary school mathematics examination is poor (Ayuba, Timayi, & Danladi, 2020; Irukana, Utete, & Kasanda, 2020; Dlamini, 2014; McIntosh & Ramagge, 2011; Mulligan and Michelmore, 1997; Anghileri, 1989). Consequently, a report by Nigeria Education Sector Analysis (ESA, 2014) showed that performance of pupils in primary mathematics is below average and the problem solving skills of the pupils are also poor. The national mean

percentage scores of primary four and six pupils in numeracy, according to the report, are 33.7% and 35.7% respectively. Mathematics teachers expressed frustrations at learners' lack of fluency in multiplication (Irukana, Utete, & Kasanda, 2020; McIntosh & Ramagge, 2011). This lack of fluency affects other mathematics topics such as fractions, division, ratio, proportion and measurement conversion that require multi-digit multiplication. Furthermore, a research carried out by Odumosu and Olusesan (2016) shows that performance in mathematics at Junior Secondary School Certificate (JSC) and Senior School Certificate Examinations (SSCE) conducted by National Examination Council (NECO) is not impressive due to learners not mastering basic mathematical concepts and competences. Evidence from past research shown that a lack skill of multiplication facts was the source of low achievement in

mathematics (Jennie & Mohd Johan, 2010; Stanley & Julaini, 2006; Sharifah et al., 2006; Aida, 2006). Learner difficulties with regard to multiplication have also been alluded to in a wide range of research (Davydov, 1991; Greer, 1992; Nunes & Bryant, 1996 and Anghileri, 2000). Hence, it is not unique to Nigerian learners.

Evidence drawn from existing literature based on how children learn multiplication indicates that many students have difficulty with what might broadly be described as multiplicative reasoning (Cheeseman & Mulligan, 2001; Misailidou & Williams, 2003; Davydov, 1991; Greer, 1992). Furthermore, a research carried out by Malola, Symons and Stephens, (2020) confirmed that it is in the development of multiplicative reasoning that the competence and confidence of many students begin to break down. This is further evidenced by research on prospective and practicing teachers who themselves show insufficient understanding of basic multiplication concepts (Ball, 1990; Graeber, Tirosh & Glover, 1989; Simon, 1993). Difficulty with multiplication problems is one of the motivations for conducting this study. More specifically, how learners can be supported to create model and strategies for multi-digit multiplication. The underlying idea is that the mathematical modeling reflects the internal mental representations in learners (Gravemeijer, 2002). Multiplicative situation involves set or group of items (multiplier), which have the

same number of items in each set (multiplicand) and the product (Greer, 1992). Hence 4×6 represents 4 groups of 6. Given 4×6 and 6×4 though they are equal expressions in value, but they can be viewed as different in representation. Drake and Barlow (2007) argue that learners who are able to recognize that 4×6 is modeled differently from 6×4 will have a better understanding of multiplication. Than those learners who are not able to differentiate the two expression. Models enable learners to make sense of their own imagination or their own worlds with regard to their internal representations. Learners understanding could be interpreted from the models that they produced and the corresponding strategies that they used linked to these models (Dlamini, 2014). Hence, one of the most commonly used model and associated strategy that can support learners in developing multiplicative thinking is the area model.

Area Model and Associated Strategies

An area model uses a rectangle divided into rows and columns to demonstrate multiplication. Anghileri (2007) emphasizes the importance of modeling using arrays and area models. Sub totals are organized so that they reflect a good understanding of place value. For example, 23 lots of 4 is the same as 20 lots of 4 added to 3 lots of 4 and this can be demonstrated using squared paper marked in the form of the area model as shows below:

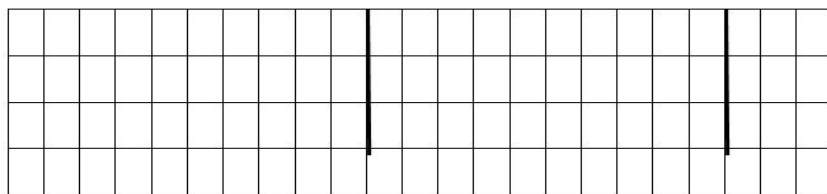


Figure 1: Squared Paper Marked in the Form of the Area Model, Source: Anghileri (2007)

This model leads into a strategy based on place value quantity decomposition of the numbers being multiplied. An area model is a truncated version of the grid model, and can be very effective for dealing with two-digit and three-digit numbers. However, the grid model should be introduced at a lower level of multiplication (two-digit by one-digit) before it can be extended for multiplying bigger numbers (Anghileri, 2007). According to Askew

(2012) learners can shift from using a representation as a "model of" a situation to being "a model for" calculating the answer and consequently being a tool for thinking and analysing with. Haylock (2010), argues that the use of area to interpret multiplication makes it easier for learners to understand multiplication of two-digit numbers. This method is based on splitting both numbers that are being multiplied into tens and units. Using an example taken

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from Hylock (2010), in simplifying 26×34 the

two numbers become $20 + 6$ and $30 + 4$.

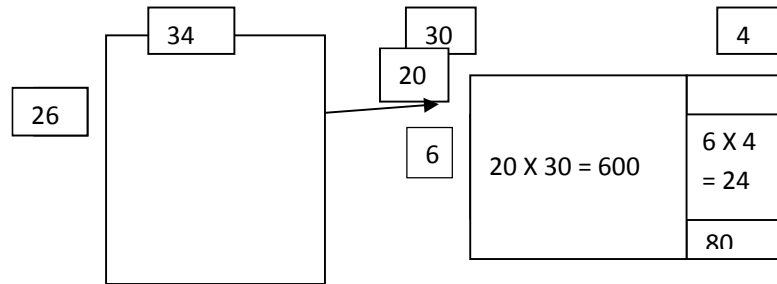


Fig. 2: Using area to interpret 26×34 (Haylock, 2010).

In the above example a more efficient representation uses the idea of a rectangle. The areas of the four rectangles are then calculated and added together. Once learners have understood the procedure and they have

become fluent with it, they may no longer need to draw the rectangles. Learners will simply set out the calculation in the form of a grid shown below:

	30	4	
20	600	80	
6	180	20	
	780	104	884

In the example above, the grid model has become “tool for” thinking with. This method enables the learners to handle the computation in a more efficient manner because they deal with friendlier numbers due to the splitting up of both numbers that are being multiplied. The area model is not only restricted to the multiplication of 2-digit numbers only, but can be extended to 3-digit numbers as well.

Researches (Ilukena, Utete, & Kasanda, 2020; Dlamini, 2014; McIntosh & Ramagge, 2011) points to the poor performance in multiplication as linked back to the ways in which multiplication is taught in schools. In our schools, despite the availability of different models for solving multiplication, there is dominant use of the intuitive multiplication model, accompanied by attempts at traditional multiplication algorithm-based strategies irrespective of the nature of the multiplication problem (Omobude, 2014; Dlamini, 2014). However, in traditional multiplication model, most learners their strategies for dealing with partial products

reveal weaknesses in lining up the digits correctly, especially when solving multi digit multiplication problems. This suggests a lack of understanding of place value among learners due to frequent use of traditional approach in schools at the expense of meaningful alternative model and strategy available for multiplication that is area model. The major problem with traditional multiplication model is that pupils do not understand fundamental multiplication concepts.

And also many incorrect ideas held by them go unchanged from the early years of the schooling to high school and sometimes beyond (Wong & Evans, 2007). By not fully and appropriately understanding fundamental concepts in multiplication, many students lose interest in learning it and have trouble understanding the more advanced concepts that build upon these fundamental concepts. Dlamini (2014) advocated that learners should be encouraged to discover patterns in solving multiplication problem leading to rules, as just giving out the rule leads to rote learning without proper understanding. So, teachers

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should evolve model that will ensure that learners understand the concepts being taught and not just memorizing for the sake of passing. To overcome this problem several studies have explored alternative models and their corresponding strategies of making the learning of multiplication exciting, relevant and comprehend. One of the model that has been canvassed as a possible solution is the use of area model. Studies, have investigated whether the use of area model can improve learners performance in multiplication. Dlamini (2014) confirmed that area model is associated with increased success in learners' multiplication performance. It is based on the above premise that this study examined the effect of Area model on primary six-pupil performance in multi-digit multiplication problem.

Many students drift away from the intuitive modeling skills they often demonstrated at a young age. If older children simply apply some of the intuitive, analytic modeling skills exhibited by young children to analyze multiplication problem, it appears that they will avoid some of their most glaring errors. Many studies have shown that, glaring errors that most of the children are facing in solving multi-digit multiplication is their inability to use appropriate strategy in their calculation process. The fundamental reason for this study was to examine the effect of Area model on primary six-pupil performance in multi-digit multiplication problem.

Purpose of the Study

The main purpose of this study was to investigate the effect of Area model on primary six-pupil performance in multi-digit multiplication problem in Bauchi State of Nigeria. The study sought to specifically find out:

1. The difference in pupils' means performance in multi-digit multiplication problems before and after the intervention lessons.
2. Find out the difference between male and female performance in multi-digit multiplication problems after the intervention lessons.

Research Questions

The following research question will guide the study.

1. What is the difference in pupils' mean performance in multi-digit multiplication problems before and after intervention lessons?
2. Is there any difference between male and female performance in multi-digit multiplication problems after the intervention lessons?

Research Hypotheses

The following null hypotheses were postulated to guide the study

H₀₁: There is no significant difference in the mean performance in multi-digit multiplication problems by primary six pupils before and after the intervention lessons.

H₀₃: There is no significant difference between male and female in performance in multi-digit multiplication problems after the intervention lessons.

METHODOLOGY

The study employed the pretest, posttest quasi experimental design involving two groups; experimental and control. The population of this study covered all the primary six (6) pupils of Bauchi Local Government Area of Bauchi State which comprised of 102 primary schools with a total enrollment of 32,200 pupils (SUBEB, 2019). The preference for these populations is based on the fact that these learners would have been fully introduced to the basic algorithms for addition, subtraction and multiplication of 2-digit by 2-digit numbers and multiplication of 3-digit by 2-digit numbers in primary four and five. Two schools were selected using the simple random procedure from which 91 (45 experimental and 46 control) pupils were selected from two intact classes as sample for the study. The selected schools were homogenous with very similar conditions in terms of staffing, provision of equipment, instructional. A validated instrument tagged: Multiplication problem Situation Test (MUPST) adapted from Askew (2012) was used to collect data for the study. It comprised of ten questions; each item of the instrument includes rich tasks for the pupils to show their performance in multiplication. MUPST had a reliability index of 0.74 when subjected to the Person Product Moment Correlation (PPMC) using the test retest method. The treatment period lasted for six weeks after which a post



test was administered. The research questions were answered from the mean and standard deviations scores while the hypotheses tested using the t-test statistics at $P \leq 0.05$ level of significance by the aid of the computer software statistical packages for social sciences (SPSS v23). The instrument for data analysis involved the use of mean, standard deviation, and t test.

RESULT

Research Question one: What is the difference in pupils' means performance in multi-digit multiplication problems before and after the intervention?

Table 1 provides the result for answering research question 1 between the mean of experimental and control group before the treatment the result indicated that experimental group have mean score of 1.97 and SD of .954, while the control group have a mean score of 1.62 and SD of .598, thus considering their mean difference of .342, this indicated that their background knowledge before the treatment is the same furthermore considering their standard deviation which fall within the same range indicated that their individual scores do not vary much.

Table 1: Means performance in multi-digit multiplication problems before the intervention.

Groups	N	Mean	Std. Deviation	Mean difference
Experimental	45	1.9714	.95442	0.3428
Control	46	1.6286	.59832	

Table 2 provides the result for answering research question 1 between the experimental and control group after the treatment the result indicated that experimental group have mean score of 9.62 and SD of .910 while control group have a mean score of 6.08 and SD of .617, thus considering their mean difference of 3.54. Clearly, the experimental

group outperformed the control group with a mean difference of 3.54. This implies that pupils in the experimental group had better performance compared to their counterpart in the control group. Furthermore considering their standard deviation which fall within the same range indicated that their individual scores do not vary much.

Table 2: Means performance in multi-digit multiplication problems after the intervention.

Groups	N	Mean	Std. Deviation	Mean difference
Experimental	45	9.6286	.91026	3.5429
Control	46	6.0857	.61787	

Research Question Two: Table 3 provides the result for answering research question 2 between the mean of male and female pupils before the treatment the result indicated that male pupils have mean score of 7.89 and SD of .798, while the female pupils have a mean score of 7.81 and SD of .997, thus considering

their mean difference of 0.082, this indicated that their knowledge and performance after the treatment is the same furthermore considering their standard deviation which fall within the same range indicated that their individual scores do not vary much.

Table 3: Male and female performance in multi-digit multiplication problems after the intervention lessons.

Group	N	Mean	Std. Deviation	Std. Error Mean
Male	38	7.8947	.79829	0.0822
Female	32	7.8125	.99798	

Research Hypotheses

H₀₁: There is no significant difference in the mean performance in multi-digit multiplication problems by primary six pupils before and after the intervention lessons.

An independent-samples t-test was conducted to compare mean performance of primary six experimental and control group in multi-digit multiplication problems before the intervention lessons. There was no significant difference in scores for experimental ($M = 1.97$,



$SD = .954$) and control group ($M = 1.62$, $SD = .598$; $t(68) = 1.80$, $p = .076$, two-tailed).

Table 4: Independent Samples Test on the difference in the mean performance in multi-digit multiplication problems by primary six pupils before the intervention lessons.

	F	Sig.	t	df	Sig. (2-tailed)	Mean Differ.	Std. Error Differ.	Decision
Equal variances assumed	1.10	.297	1.801	68	.076	.34286	.19041	Rejected
Equal variances not assumed			1.801	57.14	.077	.34286	.19041	

EVNA =

An independent-samples t-test was conducted to compare mean performance of primary six experimental and control group in multi-digit multiplication problems after the intervention lessons. There was significant

difference in scores for experimental ($M = 7.6286$, $SD = .91026$) and control group ($M = 8.08$, $SD = .817$; $t(68) = -2.21$, $p = .030$, two-tailed).

Table 5: Independent Samples Test on the difference in the mean performance in multi-digit multiplication problems by primary six pupils after the intervention lessons.

	F	Sig.	t	df	Sig. (2-tailed)	Mean Differ.	Std. Error Differ.	Decision
Equal variances assumed	1.418	.238	-2.21	68	.030	-.45714	.20685	Accepted
Equal variances not assumed			-2.21	67.23	.031	-.45714	.20685	

H_{03} : There is no significant difference between male and female performance in multi-digit multiplication problems after the intervention lessons.

An independent-samples t-test was conducted to compare mean performance of male and female primary six pupils in multi-

digit multiplication problems after the intervention lessons. There was no significant difference in scores for male pupils ($M = 7.8947$, $SD = .79829$) and female pupils ($M = 7.8125$, $SD = .99798$; $t(68) = .383$, $p = .703$, two-tailed).

Table 6: Independent Samples Test on the difference in the mean performance in multi-digit multiplication problems by male and female primary six pupils after the intervention lessons.

	F	Sig.	t	df	Sig. (2-tailed)	Mean Differ.	Std. Error Differ.	Decision
Equal variances assumed	2.2	.137	.383	68	.703	.082	.21471	Accepted
Equal variances not assumed			.376	59.04	.708	.082	.21885	

DISCUSSION

The result of the testing of hypothesis one, shows that the pupils in the experimental group who were taught multiplication using area model performed better than their counterparts in the control group. The findings is in agreement with the findings of Ilukena, Utete, & Kasanda (2020) who found a significant difference in

performance of pupils taught multiplication using area model. It also tallies with Dlamini (2014) who added that pupils performed better when exposed to area model. The post-test scores on gender showed no significant difference between the performance of male and female pupils within the experimental group who were exposed to area model. This finding agrees with the findings of Yusuf and

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Afolabi (2010) who observed that male and female students' performance in multiplication does not differ when exposed to area model.

CONCLUSION

This study examined the effectiveness of Area model using a quasi-experimental design. Based on the findings from this study, it could be concluded that teaching multiplication with area model is a more effective in boasting pupils of primary schools' multiplication performance. Moreover, it was observed that area model is gender friendly with regard to multiplication performance. These when effectively handled will hopefully lead to better performance in multiplication among pupils which they will carry with them to the secondary and tertiary levels of their educational pursuits.

RECOMMENDATIONS

Based on the findings, the following recommendations were made:

1. The use of column multiplication should be delayed to allow pupils to develop intuitive models and strategies based on problem solving and by so doing have better way of handling multi-digit multiplication problems.
2. Teachers should employ the use of area model in the teaching of multiplication and multiplicative thinking skills among pupils in primary schools to enhance their academic performance.
3. Workshops and seminars for mathematics teachers should be organized by Ministry of Education and Primary Education Board for each Local Government Education Authority in Bauchi state on the use of area model.
4. Teachers of other science based subjects should utilize instructional material in the teaching of some concepts.
5. Workshops should be organized to support mathematics teachers in preparation and delivery of similar intervention lessons so as to enhance the teaching experience

and provide better and faster methods in teaching mathematics.

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