Faculty of Natural and Applied Sciences Journal of Mathematics and Science Education
Print ISSN: 2814-0885 e-ISSN: 2814-0931
www.fnasjournals.com
Volume 5; Issue 4; March 2024; Page No. 69-77.

Flipped Classroom Model and Multiplicative Thinking Among Middle Basic Pupils of Varied Abilities in Gombe State, Nigeria

[*1]Timayi, J.M., [2]Bolaji, C., & [3]Kajuru, Y.K.
[*1]Department of Mathematics and Computer Science, College of Education Billiri, Gombe State, Nigeria.
[2 &3]Department of Science Education, Ahmadu Bello University, Zaria, Nigeria.

***Corresponding author email:** timayijoe@gmail.com

Abstract
The study examined the Effects of the Flipped-Classroom Model on multiplicative thinking and Performance in Mathematics among Middle Basic Pupils of Varied Ability, in Gombe State, Nigeria within the Solomon-Four research design. The population of the study comprised 9,717 (4,821 males and 4,896 females) pupils from public schools in Billiri and Kaltungo Local Government Areas of Gombe State. The sample for the study comprised 103 pupils (48 males and 55 females). The Pupils Multiplicative Thinking Skill Quiz (PMTSQ) with a reliability of 0.81 was used to collect data, analysed using: the t-test, analysis of variance (ANOVA) and Scheffe's test at $p \leq 0.05$ level of significance. Results revealed a significant difference in pupils' multiplicative thinking (MT) between the Flipped-Classroom Model (F-CM) and Traditional Method (TM) taught classes. Moreover, there was no significant difference in the MT of the flipped classes about ability levels (low and high). Recommendations: F-CM should be introduced to teach mathematics and make it a valid teaching model for school subjects.

Keywords: Flipped-Classroom Model, Multiplicative-Thinking, Performance, Middle Basic Pupils, Varied Ability

Introduction

The teaching and learning of mathematics as a compulsory subject at the basic level has been upheld by the National Policy on Education (NERDC, 2007; FRN, 2013). Middle Basic Education (MBE) mathematics is majorly characterized by the basic arithmetic operations of addition, subtraction, division and multiplication. From lower basic one through middle basic three (primary one through six), pupils are taught multiplication in various ways to drive home its meaning. McIntosh and Ramagge (2011) opined that fluency with multiplication reduces the cognitive load in learning later topics such as division. The natural geometric model of multiplication as a rectangular area leads to applications in measurement; hence, multiplication provides an early link between arithmetic and geometry. One of the objectives of the Basic Education curriculum in Nigeria is to develop the essential elements of problem-solving, communication, reasoning and connection within the study of mathematics (Awofala, 2012). Many learners at the basic education level in Nigeria often learn multiplication facts without gaining any real understanding of its meaning or usefulness. So, as long as they encounter mainly problems that can easily be solved using skip counting or repeated addition, they fall back on the methods that have served them adequately in the past (AliM Resource, 2012). Large-scale research on numeracy at the MBE level identified poor achievement in mathematics to be entirely due to difficulties associated with multiplication, division, fractions, decimals and proportion. This is because many students encounter difficulty in their transition to advanced mathematical thinking. Such difficulty may be explained by a lack of understanding of concepts such as multiplicative reasoning in early school years which supports the assertion that advanced mathematical thinking depends on the development of multiplicative reasoning or thinking (Carrier, 2010; Breed, 2011).

Multiplicative thinking (MT) represents the learners' mental adaptive processing of mathematical problem contexts and it is said to underpin much of the mathematics learned beyond the early middle basic education (MBE) years and it is vitally important in the development of significant mathematical concepts and understandings such as algebraic reasoning, place value, proportional reasoning, rates and ratios, measurement and statistical sampling (Hurst & Hurrell, 2014; 2016). In addition, the knowledge of division and fractions (another aspect of mathematics

Cite this article as:
Timayi, J.M., Bolaji, C., & Kajuru, Y.K. (2024 Flipped classroom model and multiplicative thinking among middle basic pupils of varied abilities in Gombe State, Nigeria. *FNAS Journal of Mathematics and Science Education, 5*(4), 69-77.

very much reliant on MT) are unique predictors of later mathematical achievement (Clarke et al., 2012; Hurst & Hurrell, 2014; Hurst & Hurrell, 2016). Jacob and Mulligan (2014) asserted that children in elementary schools represent multiplicative situations and solve word problems using concrete materials, actions with fingers, drawings and visualization. A simple definition of the term 'multiplicative thinking' is the ability to solve problems that involve multiplication and division. However, this definition is erroneous because students use a range of strategies including skip counting and repeated addition to solve multiplication and division problems. MT affects pupils' mathematical performance (MP) at the elementary level where a concrete foundation for the subject is laid. A possible way of correcting this malady is the use of a sound teaching approach which is pupil-centered. An approach which consummates the three domains of learning (cognitive, affective and psychomotor) and learning differences required for an all-round academic development at the elementary level (Iji et al., 2014).

Generally, the teaching of mathematics in Nigerian schools predominantly utilizes the conventional/traditional approach (teaching in a normal classroom with the physical presence of the teacher and students). This method of instruction has been found to inhibit the development of students' intuition, imagination and creative abilities. It is also deemed restricted to some degree and its classroom settings are teacher-centered where the teacher often talks to the students instead of encouraging them to interact, ask questions or make them understand the lesson thoroughly (Bolaji et al., 2015). To triumph, there is a need to try out other teaching methods such as the flipped-classroom model of learning which is modern and useful in this technological-driven age. Flipped learning is one of the trending paradigm shifts in pedagogy. The internet and information technology have advanced and paved a way for revolutionary changes which affect the way teachers teach and students learn. Teachers are breaking away from the role of being a knowledge provider to becoming a facilitator and coordinator of students' learning process. Flipped learning is a form of 'blended learning' that involves any employment of technology to influence learning in a classroom so that a teacher can have more time to interact with students instead of lecturing. It creates an opportunity to provide more personal feedback and assistance to students and facilitates feedback from peers about the activities being performed and material not fully understood (Lin & Chen, 2016).

The Flipped Learning Network (FLN, 2014) defines Flipped Learning as a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (Piehler, 2014). The flipped classroom model is a type of Blended Learning which is simply a learning approach that combines instructor-led brick-and-mortar classroom training and online learning activities (Thakare, 2018; Kolinski, 2022). This implies a combination of what is normally obtained in a classroom plus a touch of technology. That is the conventional method of learning plus the digital spaces complementing each other. There are many types of the flipped classroom model utilized for teaching and learning. Thakare (2018) outlined eight types of flipped classroom models used in teaching and learning depending on the variation in the distribution of study material, use of classroom time, or type of students. They are as follows: Standard Inverted Classroom (generally called flipped classroom), Micro Flipped Classroom, Discussion-Oriented Flipped Classroom, Demonstration-Based Flipped Classroom, Faux-Flipped Classroom, Group-Based Flipped Classroom, Virtual Flipped Classroom and Role-Reversal (Flipping The Teacher).

The flipped classroom model can be used at all levels of education. Its application and usability have been widely reported (Charles-Ogan & Williams, 2015; Bhagat et al., 2016; Unamba et al., 2016). Literature reported that flipped classes lead to better outcomes in mathematical performance among students (Charles-Ogan & Williams, 2015; Bhagat et al., 2016; Makinde & Yusuf, 2019; Makinde, 2020). However, researchers such as Memler (2017) and Cabi (2018) found deviations from the forgone. Every middle basic classroom is made up of pupils with varied ability levels which the teacher is expected to deal with and achieve set goals for a total development of learning irrespective of their ability. Teaching pupils on different learning levels can be difficult. A classroom may have learners of the same age range, but their learning abilities will most likely vary over a broad spectrum (Finley, 2017; Johnson, 2017). Learners are different in terms of their achievement, ability, learning and cognitive styles as well as attitudes, pace of learning, personality and motivation. The flipped classroom model is designed to deal with these traits as much as possible. Generally, 'ability level' is a term used to describe the placing of learners into separate groups of high, medium and low achievers due to their earlier assessed performance. In some other cases, the learners may be classified into low, average and advanced ability levels (Ballantyne et al., 2008). The concept of ability levels is mostly discussed to include the term 'ability grouping' which in essence is the educator's judgment of

students' ability. Supporters of ability grouping argue that there are efficiency effects to be gained for all students by putting similar students into classes that can be tailored to their abilities (Betts & Shkolnik, 2000). Consequently, this study sought to the Effects of the Flipped-Classroom Model on Multiplicative-Thinking in Mathematics among Middle Basic Pupils of Varied Ability, in Gombe State, Nigeria.

Statement of the Problem

The concepts of multiplication (and division) are components of early mathematics taught and experienced in Middle Basic Education (MBE). These concepts are the major focus of the MBE mathematics curriculum which serves as foundational topics for higher mathematics. The conceptual understanding of multiplication is crucial to the survival tactics of mathematics learners. However, multiplication is difficult for children at the primary level to perform, hence, pupils demonstrate limited understanding of the concept which results from their procedural understanding instead of their conceptual understanding. This has resulted in poor utilization of multiplicative thinking which affects pupils' future in mathematics. Pupils' later difficulty with higher mathematics can be traced to poor multiplicative thinking and teaching methodology. Teachers of basic schools commonly use the popular Traditional Method which often creates frustration and learning difficulties for pupils. With the changing paradigm in learning, teachers around the world are moving from face-to-face pedagogy (traditional method) to teaching methods that are technologically driven. These methods allow learners of different abilities to take home lessons and use classroom time for activities thereby moving classroom space to individual spaces at home. One such method is the flipped classroom model which is student-centered and found to be result-oriented. There is a great need to try out methods like this to enhance the performance of pupils at the primary school level in mathematics in Gombe state where a state of emergency was declared by the seating governor in 2021 (Aramide, 2021).

Aim and Objectives of the Study

The study examined the Effects of the flipped-classroom model on multiplicative thinking and performance in Mathematics among Middle Basic Pupils of Varied Ability, Gombe State. Specifically, the objectives of the study are to:

1. determine the effect of the Flipped-Classroom Model on the Multiplicative-Thinking of pupils when taught mathematics.
2. determine the effect of the Flipped-Classroom Model on the Multiplicative-Thinking of pupils with varied ability levels (low and high) when taught mathematics.

Research Questions

The following research questions were formulated as a guide to the study:

1. What is the difference between the Multiplicative-Thinking of pupils when taught mathematics using the Flipped-Classroom Model and the Traditional Method?
2. What is the difference between the Multiplicative-Thinking of pupils with high and low ability levels when taught mathematics using the Flipped-Classroom Model and the Traditional method?

Hypotheses

The following null hypotheses were tested at $P \leq 0.05$ level of significance.

$H0_1$: There is no significant difference between the Multiplicative-Thinking of pupils when taught using the Flipped-Classroom Model and the Traditional Method.

$H0_2$: There is no significant difference between the Multiplicative-Thinking of pupils with high and low ability levels when taught using the Flipped-Classroom Model and those taught using the Traditional Method.

Methodology

The study adopted the Solomon-Four group design within the blueprint of quasi-experimental research. The design was chosen because it allows complete control over variables that threaten both internal and external validity. The target population of the study comprised 9,717 Middle Basic pupils (MBE) of public schools in Billiri and Kaltungo Local Government Areas in Gombe State (Gombe State Ministry of Education [GSME, 2022]). Using the simple random sampling (SRS) method, eight (8) Middle Basic Five (MB 5) intact classes (four from each LGA) were selected and pretested for homogeneity. Consequently, four schools (A, B, C, & D) were found to be similar. Next, the SRS method was then observed to place the schools into experimental and control groups to participate in the research. The intact classes chosen were classified into low and high ability levels based on the pretest taken earlier.

Pupils whose score falls in the range of 0 – 49 were classified as 'Low Ability' while pupils whose scores is in the range of 50 and above were tagged into 'High Ability' groups respectively. Hence, the sample for the study was 103 pupils, deemed appropriate since it is in line with Sekaran (2000), Sambo (2008) and the central limit theorem (CLT) which recommends a minimum of 30 (N≥ 30) as a sample size for experimental research such as this one (Ganti, 2023). The study utilized the Pupils Multiplicative Thinking Skill Quiz (PMTSQ) adapted from Hurst and Hurrell (2016) and Ado and Ekwueme (2017) for MT of pupils. The reliability of PMTSO was computed to be 0.81. Pupils in the flipped classes were taught using an offline video which contained various 15-minute lessons on concepts of multiplication, division, fractions, decimals, proportion, capacity, time, weight, money, length and estimation. The non-flipped classes learnt the same concepts via the Traditional Method (TM). The research followed activities explored by Cabi (2018) shown in Figure 1 for eight (8) weeks. Thereafter, a post-test was administered to compare the effect of F-CM on pupils' MT and ability levels. With the aid of the Statistical Packages for Social Science (SPSS) software, the analysis of data collected was carried out using the t-test statistics, analysis of variance (ANOVA) and the Scheffes' multiple comparison test at p≤ 0.05 level of significance

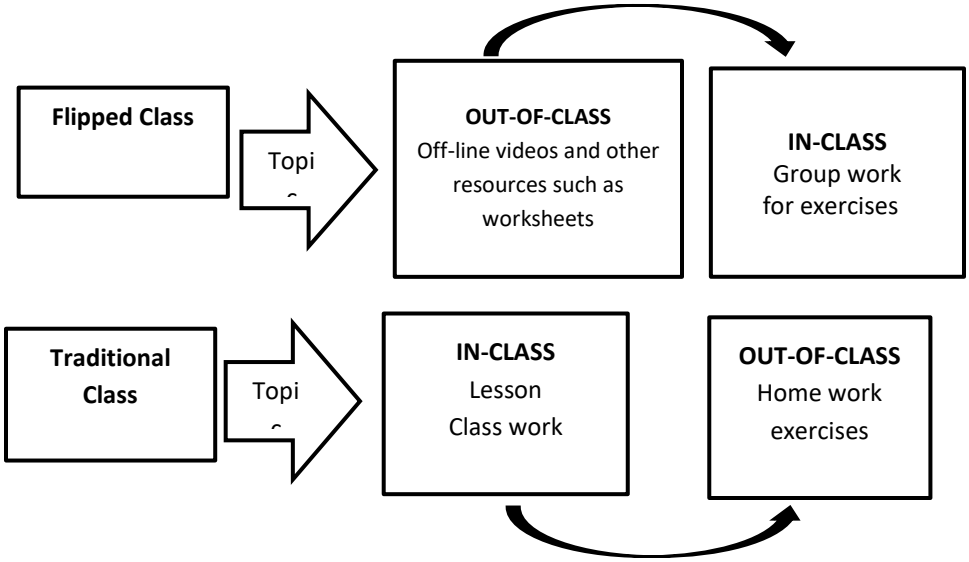

Figure 2: Summary of Activities in Flipped Classroom vs Traditional Classrooms
Source: Adopted Cabi (2018).

.

Results

Research Question One: What is the difference between the Multiplicative-Thinking (MT) of pupils when taught mathematics using the Flipped-Classroom Model and the Traditional Method?

Table 1: MT Scores of Pupils in the Experimental and Control Groups

Group	Method	N	Mean	SD	Mean Difference
Experimental	Flipped	51	61.75	9.22	
					10.42
Control	Traditional	52	51.33	4.09	

Table 1 showed that the flipped group (experimental) had a higher mean score of 61.75 compared to the non-flipped group (control) which had 51.33. The mean difference is shown to be 10.42. To establish if the difference is statistically significant, inferential statistics was used to test the null hypothesis (see Table 2).

$H0_1$: There is no significant difference between the Multiplicative-Thinking of pupils when taught using the Flipped-Classroom Model and the Traditional Method.

Table 2: Independent t-test on MT of Pupils for Experimental and Control Groups

Method	N	Mean	SD	df	t-value	p-value	Remarks
Experimental	51	61.75	9.22	101	7.437	0.001*	Reject H_{o1}
Control	52	51.33	4.09				

***Significant at $P \leq 0.05$

The independent sample t-test in Table 2 showed that the difference in test scores between the experimental (n = 51, M = 61.75, SD = 9.22) and control group (n = 52, M = 51.33, SD = 4.09) were statistically significant (t = 7.437, p = 0.001) at $\alpha = 0.05$. Therefore, null hypothesis one (**H_{o1}**) was rejected. This implied that there is a significant difference between the Multiplicative Thinking of middle-basic pupils in favour of those exposed to the Flipped Classroom Model.

Research Question Two: What is the difference between the multiplicative thinking of pupils with high and low ability levels when taught mathematics using the Flipped-Classroom Model and the traditional method?

Table 3: MT of Pupils with High and Low Ability Levels in the Experimental and Control Groups

Group	Ability	N	Mean	SD	Mean Difference
Exp I	High	11	62.82	8.95	
					4.75
	Low	14	58.07	7.45	
Exp II	High	13	68.85	4.85	
					8.85
	Low	13	60.00	9.77	
Control I	High	13	51.08	3.57	
					0.75
	Low	12	51.83	5.92	
Control II	High	14	52.71	3.65	
					2.17
	Low	13	50.54	3.71	
Total		**103**			

From Table 3 the respective mean scores for pupils with high and low ability levels on Multiplicative Thinking are Exp I (62.82 and 58.07), Exp II (68.85 and 60.00), Control I (51.08 and 51.86) and Control II (52.71 and 50.54). The high and low ability levels in the experimental groups performed better than the control groups. The mean differences are 4.75, 8.85, 0.75 and 2.17 for Exp I, Exp II, Control I and Control II groups respectively. To ascertain if the respective mean differences are significant or not, the mean scores were tested using the analysis of variance (ANOVA) statistic (see Table 4).

HO_3: There is no significant difference between the Multiplicative-Thinking of pupils with high and low ability levels when taught using the Flipped-Classroom Model and those taught using the Traditional Method.

Cite this article as:
Timayi, J.M., Bolaji, C., & Kajuru, Y.K. (2024 Flipped classroom model and multiplicative thinking among middle basic pupils of varied abilities in Gombe State, Nigeria. *FNAS Journal of Mathematics and Science Education, 5*(4), 69-77.

To test this hypothesis, the analysis of variance (ANOVA) was computed for the experimental and control groups at $p \leq 0.05$. The result is presented in Table 4.

Table 4: Summary of ANOVA on MT of Pupils with High and Low Ability Levels for Experimental and Control Groups

Source	SS	df	MS	F-value	p-value	Remark
Between Groups	3904.89	7	557.84	13.84	0.001*	Reject H_{o3}
Within Groups	3826.94	95	40.28			
Total	7731.83	102				

*****S ⟹ Significant at $p \leq 0.05$

Table 4 revealed that the difference in the mean scores among the four groups was significant [F (7,95) = 13.84, p = 0.001]. Therefore, null hypothesis three (**H_{o3}**) was rejected. After establishing a significant difference between pupils in the flipped and non-flipped classes, it was pertinent to confirm further the direction of the differences. Thus, the result was subjected to Scheffe's multiple comparison Post Hoc Test presented in Table 5.

Table 5: Scheffe's Post Hoc Test on MT among Pupils with High and Low Ability Levels for Experimental and Control Groups

(I) MTS Group levels	Mean (I)	(J) MTS Ability levels	Mean (J)	Mean Difference (I-J)	Std. Error	p-value	Remarks
Exp 1 High Ability	62.82	Exp II Low Ability	60.00	2.818	2.600	.991	**NS
		Exp 1 Low Ability	58.07	4.747	2.557	.838	**NS
		Exp II High Ability	68.85	-6.028	2.600	.616	**NS
		Control 1 Low Ability	51.83	10.985*	2.649	.023	**NS
		Control II Low Ability	50.54	12.280*	2.600	.004	*S
		Control 1 High Ability	51.08	11.741*	2.600	.008	*S
		Control II High Ability	52.71	10.104*	2.557	.038	**NS
Exp II Low Ability	60.00	Exp 1 High Ability	62.82	-2.818	2.600	.991	**NS
		Exp 1 Low Ability	58.07	1.929	2.445	.999	**NS
		Exp II High Ability	68.85	-8.846	2.489	.095	**NS
		Control 1 Low Ability	51.83	8.167	2.541	.185	**NS
		Control II Low Ability	50.54	9.462	2.489	.055	**NS
		Control 1 High Ability	51.08	8.923	2.489	.089	**NS
		Control II 2 High Ability	52.71	7.286	2.445	.274	**NS
Exp 1 Low Ability	58.07	Exp 1 High Ability	62.82	-4.747	2.557	.838	**NS
		Exp II Low Ability	60.00	-1.929	2.445	.999	**NS
		Exp II High Ability	68.85	-10.775*	2.445	.011	**NS
		Control 1 Low Ability	51.83	6.238	2.497	.516	**NS
		Control II Low Ability	50.54	7.533	2.445	.233	**NS
		Control 1 High Ability	51.08	6.995	2.445	.328	**NS
		Control II High Ability	52.71	5.357	2.399	.662	**NS
Exp II High Ability	68.85	Exp 1 High Ability	62.82	6.028	2.600	.616	**NS
		Exp II Low Ability	60.00	8.846	2.489	.095	**NS
		Exp 1 Low Ability	58.07	10.775*	2.445	.011	*S
		Control 1 Low Ability	51.83	17.013*	2.541	.000	*S
		Control II Low Ability	50.54	18.308*	2.489	.000	*S
		Control 1 High Ability	51.08	17.769*	2.489	.000	*S
		Control II High Ability	52.71	16.132*	2.445	.000	*S

*****S ⟹ Significant at $p \leq 0.05$ **NS ⟹ Not Significant at $p > 0.05$

From Table 5, it was observed that the comparison was significant with Control II's low ability (0.004). In addition, the Exp II High Ability (68.85) was found to be significant when compared with the Control I (0.011) & II low

Cite this article as:
Timayi, J.M., Bolaji, C., & Kajuru, Y.K. (2024 Flipped classroom model and multiplicative thinking among middle basic pupils of varied abilities in Gombe State, Nigeria. *FNAS Journal of Mathematics and Science Education, 5*(4), 69-77.

ability (0.000) and Control I (0.000) & II high ability (0.000. Generally, comparison within the experimental groups was not significant and the experimental groups performed better than the control groups.

Discussion

The results in Tables 1 & 2 indicate that the flipped class had better multiplicative thinking skills compared to the non-flipped class evidenced by a higher mean score which was found to be significant. This finding confirms the results of Unamba *et al.* (2016) and Makinde (2020) who reported that when learners are active within the right intervention such as the Flipped Classroom Model their MT is enhanced. From Table 3, it was observed that the flipped class had better MT skills mean scores. This difference was found to be significant when subjected to ANOVA and Scheffe's comparison test (see Tables 4 and 5). Hence, the F-CM enhances MT levels in pupils with varied abilities better than the Traditional Method. This aligns with Charles-Ogan and Williams (2015), Unamba *et al.* (2016) and Makinde (2020) who reported that when learners are active within the right intervention such as provided by the F-CM, their MT is enhanced. In particular, Hurst and Hurrell (2016), and Ado and Ekwueme (2017) desired a better environment for improving MT in children which the F-CM provides. However, this finding negates Memler (2017) and Cabi (2018) who found no significant differences between the flipped and non-flipped scores.

Conclusion

Based on the findings and discussion of the study, the following conclusions were made: The F-CM is effective at improving the MT skills of middle-basic pupils needed for problem-solving and the development of advanced mathematical thinking. The MT skills of male and female pupils exposed to the F-CM improved better than the traditional method group. In particular, the pupils improved similarly which indicated that the F-CM is gender friendly. A direct consequence is that; the F-CM can be used extensively in all forms of schools at the middle basic level whether it is co-education or not because it has the same effect on gender. Ability level (high and low) differences among pupils concerning MT skills were observed to be closed up within the F-CM. In addition, pupils in the flipped class improved better compared to their counterparts in the traditional method class. This finding is of utmost importance as every classroom at the middle basic level has pupils of varied abilities. Hence, the F-CM can help close up such gaps leading to pupils performing similarly even in standardized examinations which has been a mirage in the education system.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. The Flipped-Classroom Model (F-CM) should be used by teachers at the MBE level to teach mathematics because it provides an exciting learning environment for pupils which can enhance their Multiplicative Thinking (MT) skills.
2. Pupils should be encouraged by their teachers to watch videos which teach mathematics and other school subjects to enhance their learning such as U-lesson (e-learning).
3. Curriculum developers should incorporate and encourage video lessons as part of the pedagogical method to enhance the teaching and learning of mathematics at the MBE level.
4. Conferences, seminars and workshops should be organized by professional associations/bodies and research organisations like the Mathematical Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN) and the Nigeria Educational and Research Development Council (NERDC) to incorporate the Flipped-Classroom Model (F-CM) in mathematics curriculum and textbooks at all primary school levels.

References

AliM Resource (2012). *Accelerative learning in mathematics*. Accessed 5th August, 2017 from http://nzmaths.co.nz/accelerating-learning 3. Zealand Ministry of Education

Aramide, M. (2021). *Gombe declares an emergency in education*. https://guardian.ng/news/gombe-declares-emergency-in-education/

Awofala, A. O. A. (2012). An analysis of the new 9- year basic education mathematics curriculum in Nigeria. *Acta Didactica Napocensia, 5*(1), 17 – 28.

Ballantyne A. O., Spilkin, A. M., Hesselink, J., Trauner, D. A. (2008). Plasticity in the developing brain: intellectual, language and academic functions in children with ischaemic perinatal stroke. *Brain, 131*(Pt 11):2975-85. doi: 10.1093/brain/awn176. Epub 2008 Aug 12. PMID: 18697910; PMCID: PMC2577808.

Betts, J. R., & Shkolnik, J. L. (2000). The effects of ability grouping on student achievement and resource allocation in secondary schools. *Economics of Education Review, 19* 1–15

Bhagat, K. K., Chang, C. N., & Chang, C. Y. (2016). The Impact of the Flipped Classroom on Mathematics Concept Learning in High School. *Educational Technology & Society, 19* (3), 134–142.

Bolaji, C., Kajuru, Y. K., & Timayi, J. M., (2015). Effects of Jigsaw IV cooperative learning strategy (J4CLS) on academic performance of secondary school students in geometry. *International Journal of Mathematics Trends and Technology*, 28(1), 12-18.

Breed, M. H. (2011). *Constructing paths to multiplicative thinking: breaking down the barriers.* PhD Thesis, RMIT University Australia.

Cabi, E. (2018). The impact of the flipped classroom model on students' academic achievement. *International Review of Research in Open and Distributed Learning, 19* (3), 202 - 221

Carrier, J. A. (2010). *Indicators of multiplicative reasoning among fourth grade students. The University of North Carolina at Greensboro, ProQuest Dissertations Publishing, 2010. 3403677.* Retrieved from https://search.proquest.com/docview/366627761

Charles-Ogan, G., & Williams, C. (2015). Flipped classroom versus a conventional classroom in the learning of mathematics. *British Journal of Education, 3*(6), 71-77. ISSN 2054-636X (online)

Clarke, D.M., Clarke, D.J. & Sullivan, P. (2012). Important ideas in mathematics: What are they and where do you get them? *Australian Primary Mathematics Classroom, 17*(3), 13 - 18.

Federal Republic of Nigeria [FRN] (2013). *National policy on education.* 6th Edition. NERDC, Nigeria.

Finley, T. (2017). *Teaching a class with big ability differences*. Retrieved from https://www.edutopia.org/article/teaching-class-big-ability-differences-todd-finley

Flipped Learning Network (2014). *The Four Pillars of FLIP*. Retrieved from http://www.ssfudes.com/veille/leveilleur/wp- content/uploads/2014/09/

Ganti, A. (2023). Central limit theorem (CLT): Definition and key characteristics. *Last accessed from Investopedia March*, *16*, 2023.

Gombe State Ministry of Education [GSME, 2022]. *Statistics of Students Enrollment.* Gombe State Ministry of Education.

Hurst, C., & Hurrell, D. (2014). Developing the big ideas of numbers. *International Journal of Education Studies in Mathematics, 1* (2), 1 – 18

Hurst, C., & Hurrell, D. (2016). Investigating children's multiplicative thinking: implications for teaching. *European Journal of STEM Education, 1* (3), 1 – 11.

Iji, C. O., Ogbole, P.O., Uka, N. K. (2014). Effect of improvised instructional materials on students' achievement in geometry at the upper basic educational level in Makurdi metropolis, Benue State, Nigeria. *American Journal of Educational Research, 2(7), 538-542.*

Jacob, L., & Mulligan, J. (2014). Using arrays to build towards multiplicative thinking in the early years. *Australian Primary Mathematics Classroom, 19*(1), 35 – 40.

Johnson, A. (2017). *How to teach students with different learning abilities*? Retrieved February 24th 2018 from https://study.com/blog/how-to-teach-students-with-different-learning-abilities.html

Kolinski, H. (2022). *What Is Blended Learning?* Retrieved from https://www.ispringsolutions.com/blog/blended-learning-a-primer

Lin, P., & Chen, H. (2016). The effects of flipped classroom on learning effectiveness: using learning satisfaction as the mediator. *World Transactions on Engineering and Technology Education, 14* (2), 231 – 244.

Makinde, S. O., & Yusuf, M. O. (2019). The flipped classroom: its effects on students' performance and retention in secondary school mathematics classroom. *International Journal for Innovative Technology Integration in Education,* 117 – 126.

Makinde, S. O. (2020). Impact of Flipped Classroom on Mathematics Learning Outcome of Senior Secondary School Students in Lagos, Nigeria. *African Journal of Teacher Education, 9*(2), 23-42.

Mcintosh, J., & Ramagge, J. (2011). *Improving mathematics education in schools (TIMES) Project: multiplication and division.* International Centre of Excellence for Education in Mathematics pp5.

Memler, J. (2017). *The effect of a flipped classroom on student academic achievement and the gender gap in high school physics.* PhD Dissertation, University of Georgia, USA.

Nigerian Educational Research and Development Council (2007). *9-year Basic Education Curriculum, Mathematics for Middle Basic Education Primary 4-6.* NERDC Press, Lagos.

Piehler, C., (2014). FLN *Shares its Four Pillars of Flipped Learning*, Retrieved May 1, 2015 from:

URL:http://thejournal.com/articles/2014/03/12/fln-announces-formal-definition-and-fourpillars.aspx
Sambo, A. A. (2008). *Research methods in education.* Lagos: Stirling-Horden Publishers (Nig.) Ltd pg 341 – 354.
Sekaran, U., 2000. *Research Method for Business (3rd Ed.)*. New York: John Wiley & Sons, Inc.
Thakare, R. (2018). *8 Types of flipped learning classrooms and tools to build them.* Retrieved from https://elearningindustry.com/flipped-learning-classrooms-tools-build-types
Unamba, E. C., Izuagba, N. J., & Ogbonnaya, C. N. (2016). Engagement and promote active learning among Primary school pupils in algebra. *Journal of Teacher Perspective, 11*(1), 189 - 210