Nigerian Journal of Physics (NJP)

ISSN: 1595-0611

Volume 32(3), September 2023

Assessment of Mathematıcal Workıng Memory Among Varıed Abılıty Level Prımary School Pupıls Wıthın a Flıpped-Classroom Model for Scıence Educatıonal Development

***Timayi, J. M., Chomo, H. J., Gwandum, S. G.**
Department of Mathematics and Computer Science, College of Education Billiri, Gombe State.

*Corresponding author's email: timayijoe@gmail.com Phone: +2348036426686

ABSTRACT
The study is an assessment of mathematıcal workıng memory among varıed abılıty level prımary school pupıls wıthın a flıpped-classroom model for scıence educatıonal development via the blueprint of Solomon four research design. The sample for the study comprised 103 pupils (48 males and 55 females). Two (2) validated instruments: Cogmed Working Memory Checklist (CWMC) and the Pupils Mathematics Performance Test (PMPT) with respective reliabilities of 0.87 and 0.78 were used to collect data for the study. Three null hypotheses were tested using the t-test, analysis of variance (ANOVA) and the Scheffe's test at p≤ 0.05 level of significance. The results revealed a statisitcally significant difference between the Mathematical Working Memory (MWM) of pupils in the flipped class (F-CM) and the Traditional Method (TM). In addition, it was observed that the MWM of pupils with low and high ability levels differ significantly between the F-CM and TM groups. Moreover, a significant difference was observed between the Mathematics Performance (MP) of pupils in the F-CM and the TM class. Generally, within the F-CM groups the MWM were observed to have improved significantly better than that of the TM groups. The study recommends regular assessment of MWM by teachers among pupils for future scıence education (Physics, Mathematics, Chemistry and Biology) development. Also, school administrators should ensure a periodic assessment of pupils MWM by teachers in order to enhance science education for sustainable development.

Keywords:
Assessment,
Flipped-classroom model,
Mathematical working memory,
Science education,
Varied ability.

INTRODUCTION

The primary school is the foundational point where mathematics is introduced to pupils. İt is critical and important that pupils understand every mathematical concept taught by their teachers at this level. This is because these concepts are building blocks for later and higher mathematics the pupils will encounter in life. A facilitator of the ability to internalized and solve problems in mathematics is the Working Memory Capacity [WMC] (Bresgi et al., 2017; van Bueren et al., 2022). Pupils' utilization of their working memory resource is expediant in enhancing their performance at the subject.

The WMC refers to a brain system that provides temporary storage and manipulation of information necessary for complex cognitive tasks as language comprehension, learning and reasoning. It involves controlling, regulating and actively maintaining relevant information to accomplish complex cognitive tasks such as mathematical processing (Anas & Sasangohar, 2017). WMC also referred to as Mental Workspace (MW) is one of the reductive factors for mathematical achievement in learners (Alamolhodaei, 2009; Raghubar *et al*, 2010). İn this research, the WMC will be referred to as Mathmatical Working Memery (MWM). This is to relate it to mathematics.

Poor MWM affects pupils' mathematical performance (MP) at the elementary level where concrete foundation for the subject is laid. A possible way of correcting this malady is the use of sound teaching approach which is pupil-centered. An approach which consummates the three domain of learning (cognitive, affective and psychomotor) and learning differences required for an all-round academic development at the elementary level. Iji *et al* (2014) submitted that the use of effective methodology in the teaching and learning of mathematics which emphasizes active learning, could be explored to tackle problems in the teaching and learning of the subject. The teaching of mathematics in Nigerian schools is predominantly via traditional approach (face-to-face pedagogy) which has been found to inhibit the development of learners' intuition, imagination and creative abilities. It is also deemed restricted being teacher-centered and learner-passive environment

(Anyichie & Onyedike, 2012; Eze et al, 2015). Hence, there is a need to try out other teaching methods such as the flipped-classroom model of learning which is modern, trending and appealing to learners of different ability levels in this technological driven age.
Flipped learning is one of the trending paradigm shift in pedagogy especially with the Covid 19 era which adversely affected many countries' educational system, Nigeria's inclusive. Recent developments in education shows that teachers are breaking away from the role of being a knowledge provider to becoming a facilitator and coordinator of learners' learning process. Flipped learning as a form of 'blended learning' inculcates the use of any technology to influence learning so that a teacher can have more time to interact with learners. It also creates an opportunity to receive feedbacks, assist learners (with identified problems) and facilitates classroom activities (Wiley & Gardner, 2013; Lin & Chen, 2016). The Flipped Learning Network (FLN) defines Flipped Learning as a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space. In addition, 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).
In the Flipped Classroom Model (F-CM), the teacher and students focus on the upper levels of the Blooms' taxonomy which are applying, analyzing, evaluating, and creating. This is in contrast to the traditional Method whose focus is the lower level of the Blooms' taxonomy as represented in figure 1 (Reyes-Lozano *et al*, 2014; Lopes & Soares, 2018).

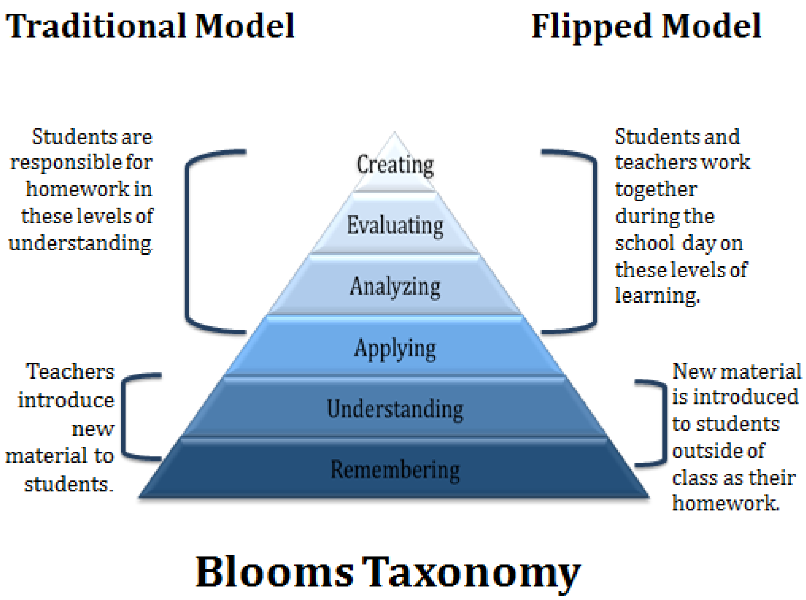

Figure 1: Blooms Taxonomy
Source: Lopes & Soares (2018)

An advantage of the F-CM is that it caters for the various ability levels a teacher is faced with in a class room setting. Nigerian classrooms are made up of learners of varied ability levels for which there is a prescribed set of objectives and learning experiences. Teaching pupils of different learning abilities can be challenging. This is because learners are different in terms of their achievement, performance, learning and cognitive styles. In addition, distinction is seen in attitudes, pace of learning, personality and motivation. The F-CM is designed to deal with these traits as much as possible.
Generally, literature posits that the F-CM enhances performance among leaners when compare with the Traditional Method (Charles-Ogan & Williams, 2015; Bhagat et al, 2016; Unamba, 2016; Tang *et al*, 2017; Makinde & Yusuf, 2019; Makinde, 2020; Wei *et al*, 2020). However, studies such as Cabi (2018) found no significant difference between the performance of the flipped and non-flipped classes in mathematics. İn addition, Osei-Boadi (2016), Nazir *et al* (2018) and Zhang *et al.* (2018) are of the view that when children are exposed to good learning methodology and environment their WMC is enhanced. Moreover, it was observed that low ability level pupils can demonstrate better WMC when exposed to an appropriate intervention such as provided by the F-CM (Zhang *et al*,2018). Consequently, this study is an assessment of mathematıcal workıng memory among varıed abılıty level prımary school pupıls wıthın a flıpped-classroom model for scıence educatıonal development

Statement of the Problem

The primary school is the focal point and where foundation mathematical concepts are taught. However, it has been observed that pupils performance has not been satisfactory. A latent factor responsible is the issue of MWM among children. In addition, Studies show that the antecedent of failure and poor performance of students in mathematics can be traced to the achievement in the subject at the primary school. Poor MWM affects pupils performance in mathematics especially where the methodology utilized in teaching the subject is faulty. Many teachers at the primary schools commonly use the traditional method which is teacher-centered and often creates frustration and learning difficulties for pupils. With the changing paradigm in learning, teachers around the world are moving from the face-to-face pedagogy (traditional method) to teaching methods that are technologically driven. One of such methods is the flipped classroom model which is student-centered and found to be result oriented. Consequently, this study aimed at the an assessment of mathematıcal workıng memory among varıed abılıty level prımary school pupıls wıthın a flıpped-classroom model for scıence educatıonal development.

Objectives of the Study

Specifically, the objectives of the study are:

i. Investigate the effect of F-CM on the MWM of pupils when taught mathematics.
ii. Determine the MP of pupils when taught using the F-CM.
iii. Investigate the effect of F-CM on the MWM of pupils with varied ability levels (low and high) when taught mathematics.

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

i. **HO_1:** There is no significant difference between the MWM of pupils in mathematics when taught using F-CM and the TM.
ii. **HO_2:** There is no significant difference between the MP of pupils in mathematics when taught using F-CM and the TM.
iii. **HO_3:** There is no significant difference between the MWM of pupils with high and low ability levels taught using F-CM and the TM.

MATERIALS AND METHODS

This study adopted the Solomon four group design (Creswell & Creswell, 2018). The target population of the study comprised 9,717 (4,821 males and 4,896 females) primary five school pupils of public schools in Billiri and Kaltungo Local Government Areas in the Southern Senatorial zone of Gombe State, Nigeria. A sample of 103 pupils (male = 48 and female = 55) were selected from four randomly selected schools and intact classes. The sample size met the dictates of the central limit theorem which recommends a minimum of 30 ($N \geq 30$) (Sambo, 2008; Ganti, 2021). Moreover, 51 pupils (male = 23 and female = 28) were tagged experimental group and 52 pupils (male = 25 and female = 27) control groups. Based on a pretest given earlier, pupils whose score fall in the range of 0 – 49 were classified as 'Low Ability' while pupils whose score is in the range of 50 and above were placed in the 'High Ability' groups respectively (See Table 1).

Table 1. Sample for the Study

Group	Low Ability	High Ability	Total
Experimental Group I	11	14	25
Control Group I	12	13	25
Experimental Group II	13	13	26
Control Group II	13	14	27
	49	**54**	**103**

Two instruments namely: Cogmed Working Memory Checklist (CWMC) and Pupils Mathematics Performance Test (PMPT) were used to collect data for the study. The Cogmed Working Memory Checklist (CWMC) was adopted from Pearson Cogmed (2018). It is a 15 item checklist developed for checking and easy identification of children with working memory deficits. It is a checklist used by the teacher to identify memory as a source of difficulty in children with working memory problems during classroom functioning. It is a quick and efficient way for early identification of working memory problems that can impair learning. The CWMC is a five point Likert type scaled checklist having responses of 'not at all', 'a little', 'rather', 'much' and 'very strong', which was scored 0, 1, 2, 3 and 4 respectively. The scoring was rated on a scale of 0 - 100% with scores closer to 0% termed better than scores approaching 100%. A pupil's score was determined by adding score obtained from each of the 15 items on the checklist and recorded.

PMPT is a two sectioned quiz adopted from Hurst and Hurrell (2016) and Ado & Ekwueme (2017) while MBMPT is a 25 multiple choice objective test with three distracters and one answer (lettered A – D) developed by the researcher to cover basic primary mathematics content involving multiplication and division. The computed reliabilities of CWMC and MBMPT are 0.87 and 0.78 via the Split-half and test retest method respectively obtained.

The pupils in experimental groups were taught using the F-CM using an offline video. Each video lesson has a duration of 15 minutes. A post-test was administered after treatment to determine the effect of F-CM on pupils WMC and MP. The Control groups were taught the same concepts using the Traditional Method (TM). Both groups were taught for eight weeks after which they were post tested. Figure 2 shows a summary of activities for both groups in the study.

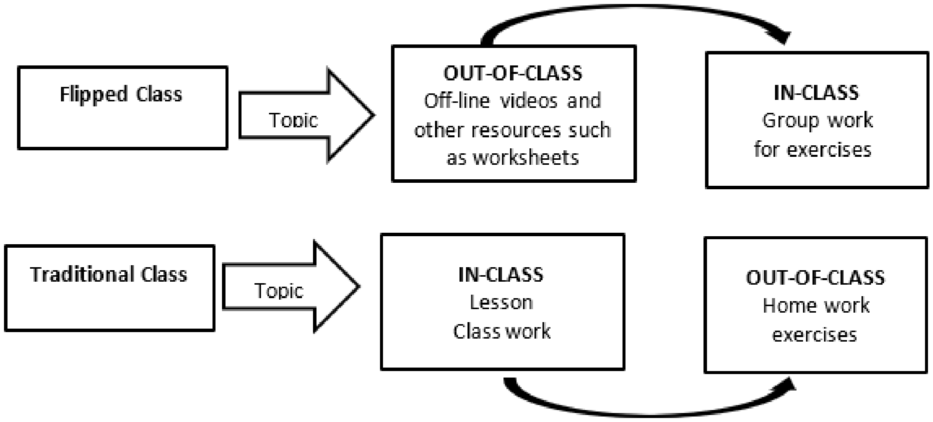

Figure 2: Summary of Activities in Flipped Classroom vs Traditional Classrooms
Source: Adopted Cabi (2018).

Data collected was analyzed using the t-test statistics, analysis of variance (ANOVA) and the Scheffes' multiple comparison test at p≤ 0.05 level of significance via the Stattistical Packages for Social Science (SPSS) software.

RESULTS AND DISCUSSION

HO₁: There is no significant difference between the MWM of pupils in mathematics when taught using F-CM and the TM.

Table 2: Independent t-test Results on MWM of Pupils in Experimental and Control Groups

Group	N	Mean	SD	df	t-value	p-value	Remarks
Experimental	51	20.98	4.97	101	7.565	0.001*	Reject H_{o2}
Control	52	37.27	14.57				

***Significant at P ≤ 0.05**

The independent sample t-test in Table 2 showed that the difference in test score between the experimental (n = 51, M = 20.98, SD = 4.97) and control (n = 52, M = 37.27, SD = 14.57) groups was statistically significant (t = 7.565, p = 0.001) at 0.05 level of significance. Therefore, the null hypothesis two (**H_{o1}**) was rejected. This implied that there is a significant difference between the MWM of middle basic pupils in favour of those exposed to the Flipped classroom model.

HO_2: There is no significant difference between the MP of pupils in mathematics when taught using F-CM and the TM.

In order to test this hypothesis, an independent sample t-test was computed at p≤ 0.05. The result is presented in Table 3.

Table 3. Independent sample t-test statistics for MP of Pupils in the Four Groups

Group	N	Mean	SD	df	t-value	p-value	Remarks
Flipped	51	75.41	12.98	101	10.836	0.001*	Reject H_{o2}
Non Flipped	52	49.62	11.13				

***Significant at P ≤ 0.05**

Table 3 revealed a statistical difference in test score between the experimental (n = 51, M = 75.41, SD = 12.98) and control (n = 52, M = 49.62, SD = 11.13) groups (t = 10.836, p = 0.001) at 0.005 level of significance. Thus, the null hypothesis three (**H_{o2}**) was rejected.

HO_3: There is no significant difference between the MWM of pupils with high and low ability levels taught using F CM and the TM.

To test this hypothesis, the analysis of variance (ANOVA) was computed at $p \leq 0.05$ (see Table 4).

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

Source	Sum of Squares	df	Mean Square	F-value	p-value	Remark
Between Groups	9097.98	7	1297.00	12.56	0.001*	Reject H_{o3}
Within Groups	9809.74	95	103.26			
Total	18888.72	102				

***S** ⟹ Significant at $p \leq 0.05$

From Table 4, the difference in mean scores among the four groups was statistically significant [f (7,95) = 12.56, p = 0.001]. This implied that mean scores on MWM between pupils in the experimental and control groups significantly differ. Consequently, the null hypothesis three (**H_{o3}**) was rejected. Next, the result was subjected to the Scheffe's multiple comparison Post Hoc Test to ascertain the direction of the differences. This is presented in Table 5.

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

(I) WMC Ability levels	Mean (I)	(J) WMC Ability levels	Mean (J)	Mean Difference (I-J)	Std. Error	p-value	Remarks
Exp 1 High Ability	22.18	Exp II Low Ability	21.85	.336	4.163	1.000	**NS
		Exp 1 Low Ability	19.86	2.325	4.094	1.000	**NS
		Exp II High Ability	20.31	1.874	4.163	1.000	**NS
		Control 1 Low Ability	46.58	-24.402*	4.242	0.000	*S
		Control II Low Ability	34.08	-11.895	4.163	0.329	**NS
		Control 1 High Ability	40.46	-18.280*	4.163	0.012	**NS
Exp II Low Ability	21.85	Exp 1 High Ability	22.18	-.336	4.163	1.000	**NS
		Exp 1 Low Ability	19.86	1.989	3.914	1.000	**NS
		Exp II High Ability	20.31	1.538	3.986	1.000	**NS
		Control 1 Low Ability	46.58	-24.737*	4.068	0.000	*S
		Control II Low Ability	34.08	-12.231	3.986	0.238	**NS
		Control 1 High Ability	40.46	-18.615*	3.986	0.005	*S
		Control II 2 High Ability	29.29	-7.440	3.914	0.820	**NS
Exp 1 Low Ability	19.86	Exp 1 High Ability	22.18	-2.325	4.094	1.000	**NS
		Exp II Low Ability	21.85	-1.989	3.914	1.000	**NS
		Exp II High Ability	20.31	-.451	3.914	1.000	**NS
		Control 1 Low Ability	46.58	-26.726*	3.998	0.000	*S
		Control II Low Ability	34.08	-14.220	3.914	0.080	**NS
		Control 1 High Ability	40.46	-20.604*	3.914	0.001	*S
		Control II High Ability	29.29	-9.429	3.841	0.540	**NS
Exp II High Ability	20.31	Exp 1 High Ability	22.18	-1.874	4.163	1.000	**NS
		Exp II Low Ability	21.85	-1.538	3.986	1.000	**NS
		Exp 1 Low Ability	19.86	.451	3.914	1.000	**NS
		Control 1 Low Ability	46.58	-26.276*	4.068	0.000	*S
		Control II Low Ability	34.08	-13.769	3.986	0.117	**NS
		Control 1 High Ability	40.46	-20.154*	3.986	0.002	*S
		Control II High Ability	29.29	-8.978	3.914	0.629	**NS

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

Table 5 showed that the mean differences was only significant with Control I low ability (0.000). Also, the comparison was found to be significant with Control I High Ability (0.005, 0.002). Generally, the experimental group had lower mean scores which according to the scale of the Cogmed Working Memory Checklist was better. This was attributed to the effect of treatment administered.

Discussion

In Table 3, the t-test computed showed a significant difference between the flipped class and the traditional method class in favour of the former. This finding was found to be consistent with Osei-Boadi (2016), Nazir *et al* (2018) who reported that MWM in children can be enhanced given the right intervention such as provided by the F-CM environment.

From the result presented in Table 4, pupils in the F-CM group outperformed the TM group. This finding confirms the report of Bhagat *et al*, (2016), Tang *et al.* (2017), Makinde (2020) and Wei *et al.* (2020) who reported better performance of learners in mathematics when exposed to the F-CM. The finding also negates Cabi (2018) who found no significant difference between the performance of the flipped and non-flipped in mathematics.

The summary of ANOVA in Table 4 showed a significant difference between the MWM scores of the flipped class and the traditional method class with regart to ability levels. A post Hoc test (Table 5) confirmed the difference was significant only between flipped and traditional classes. The MWM of pupils in the flipped class were found to be non-significant with regard to low and high ability level. These findings validates Osei-Boadi (2016), Nazir *et al.* (2018) who asserted that WMC in children can be enhanced given the right intervention such as the flipped class environment in the study. In addition, Zhang *et al.* (2018) are of the view that children with low ability level can demonstrate a better MWM when exposed to an appropriate intervention such as provided by the F-CM.

CONCLUSION

The findings of the study, show that the F-CM is effective at improving the MWM and MP of pupils compared to the TM. The gap among pupils due to varied ability (low and high) can be closed using the F-CM. This established that the F-CM is more effective compared to the TM among primary school pupils in mathematics pedagogy. Hopefully, Science, Technology, Engineering and mathematics (STEM) related fields will thrive beyond what our expectation.

The F-CM should be used by teachers at the primary school level to teach mathematics because it provides an exciting learning environment for pupils which can enhance better MWM and MP. İn addition, teachers should encourage pupils to participate in the flipped classroom by watching videos thereby exposing them to modern/ technological driven approach to learning. Also, curriculum developers should incorporate and encourage video lessons as part of pedagogical method to enhance the teaching and learning of mathematics at the primary school level. Parents should endeavour to buy or provide flipped model videos for their wards and encourage them to watch them at home instead of cartoons.

REFERENCES

Ado, I. B., & Ekwueme, C. O. (2017). Influence of Pupils' Reasoning Ability and Gender on their Multiplicative Thinking. *Journal of education & entrepreneurship, 4*(10), 24 – 38. https://doi.org/10.26762/jee.2017.40000002

Alamolhodaei, H. (2009). A working memory model applied to mathematical word problem solving. *Asia Pacific Education Review. 10*. 183-192. 10.1007/s12564-009-9023-2.

Anas, S., & Sasangohar, F. (2017). Investigating the role of working memory components in mathematical cognition in children: a scoping review. *Proceedings of the Human Factors and Ergonomics Society 2017 Annual Meeting, 417 - 421*

Anyichie, A. C., & Onyedike, C. C. (2012). Effects of self-instructional learning strategy on secondary school students' academic achievement in solving mathematical word problems in Nigeria. *International Multidisciplinary Journal Etheopia, 6*(4), 302-323.

Baddeley, A. D. (1992). Working memory. *Science, 255*, 556-559.

Baddeley, A. D. (2003). Working memory: looking back and looking forward. Nat. Rev. Neurosci, 4, 829 – 839. Doi: 10.1038/nrn1201

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.

Bresgi, L., Alexander, D. L. M., & Seabi, J. (2017). The predictive relationships between working memory skills within the spatial and verbal domains and mathematical performance of grade 2 South African learners. *International Journal of Educational Research, 81*, 1-10

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

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.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches*(5thed.). Los Angeles: Sage.

Eze, T. I., Ezenwafor, J. I. & Molokwu, L. I. (2015). Effect of meta-learning teaching method on the academic performance of building trades students in technical colleges in South-east Nigeria. *International Journal of Technical Vocational Education, 7*(10), 101 – 108.

Ganti. A. (2023). Central limit theorem (CLT): Definition and key characteristics. https://www.investopedia.com/terms/c/central_limit_theorem.asp

Gathercole, S. E., & Alloway, T. P (2007). *Understanding working memory: A Classroom Guide.* Harcourt Assessment, London United Kingdom.

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.*

Lopes, A. P., & Soares, F. (2018). Flipping a mathematics course, a blended learning approach. *Proceedings of INTED2018 Conference 5th-7th March 2018, Valencia, Spain.* 3844-3853. 10.21125/inted.2018.0749.

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.

Nazir, A., Rana, R. A., & Khan, K. A. (2018). Effect of working memory on students' attitude towards mathematics at secondary level. *Pakistan Journal of Education, 35*(3), 97-118

Osei-Boadi, B. (2016). The Role of Working Memory Capacity in Math Performance. *Undergraduate Honors Theses. Paper 34.* Retrieved from https://ir.lib.uwo.ca/cgi/viewcontent.cgi?article=1034&context=psychK_uht

Raghubar, K. P., Barnes, M. A., & Hecht, S. A. (2010). Working memory and mathematics: a review of developmental, individual difference, and cognitive approaches. *Learning Individual Differences, 20*(2):110-122.

Reyes-Lozano, C. A., Meda-Campaña, M. E., & Morales-Gamboa, R. (2014). Flipped classroom as educational technique to teach math on a competencies-based approach: case study. *Latin American Conferences on Learning Objects and technologies. 20 – 24th October. Manizales Columbia.*

Roscoe, J. T. (1975). *Fundamental Research Statistics for the Behavioral Sciences. (2nd Ed.).* New York: Holt, Rinehart and Winston.

Sambo, A. A. (2008). *Research methods in education.* Lagos: Stirling-Horden Publishers (Nig.) Ltd pg 341 – 354.

Tang, F., Chen, C., Zhu, Y., Zuo, C., Zhong, Y., Wang, N., Zhou, L., Zou, Y., & Liang, D. (2017) Comparison between flipped classroom and lecture based classroom in ophthalmology clerkship. *Medical Education Online, 22,* 1, 1395679, DOI: 10.1080/10872981.2017.1395679

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

van Bueren N. E. R., van der Ven, S. H. G., Roelofs, K., Cohen Kadosh, R., & Kroesbergen, E. H. Predicting math ability using working memory, number sense, and neurophysiology in children and adults. *Brain Science,* *12*(5):550. doi: 10.3390/brainsci12050550. PMID: 35624937; PMCID: PMC9139259.

Zhang, H., Chang, L., Chen, X., Ma, L., & Zhou, R. (2018). Working memory updating training improves mathematics performance in middle school students with learning difficulties. Front. Hum. Neurosci, 12, 154. Doi: 10.3389/fnhum.2018.00154