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EFFECT OF PARTITIVE VARIATION TEACHING STRATEGY ON PUPIL'S MOTIVATION AND PERFORMANCE IN BASIC SCHOOL ALGEBRA IN BENUE STATE, NIGERIA

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ABSTRACT

This study investigated the effect of partitive variation teaching strategy on pupils' motivation and academic performance in basic five algebra in Benue state, Nigeria. The quasi experimental, pretest-posttest design was adopted for the research. Four schools were systematically selected in Zone B education zone of the state. There were 113 pupils (54 male, 59 female) in the experimental group and 141 pupils (77 male, 64 female) in the control group. Two research questions and two hypotheses guided the study. There were two instruments used for the study: the algebra performance test (APT) which was an objective test and the Algebra Motivation Questionnaire (AMQ). These were administered on the respondents before and after teaching using carefully prepared lesson plans for both groups of pupils. The experimental procedure took 6 weeks from training to completion. The data collected were analysed using SPSS for Windows analytical software. Means and standard deviations were used to answer the research questions. The multivariate analysis of covariance (MANCOVA) was used to compare the means of motivation ratings, while analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. Findings revealed that there was statistically significant difference $F(6,490) = 44.64$; $P = 0.00 < 0.05$ in the mean motivation ratings and mean performance $F(3,245) = 43.12$; $P = 0.00 < 0.05$ between the experimental and control groups. The study concluded that the partitive variation teaching strategy motivates pupils and improves algebra performance among Basic 5 pupils.

Keywords:partitive variation, motivation, performance, algebra, Basic school

INTRODUCTION

Mathematics education undoubtedly takes center stage in a world of unending scientific and technological advancements, as human kind continually seeks answers to questions about its needs and those of the society. Countries continue to place premium on the teaching and learning of school mathematics. Students need to acquire mathematical

knowledge and skills to compete and survive in life as well contribute their own quota to their immediate society and the world at large. These skills include logical reasoning, problem solving, and the ability to think in abstract ways. The challenge in education today however, is to effectively teach students of diverse ability and different pace of learning so they are able to learn mathematics by developing positive motivation and improved performancesin mathematics learning.

Motivational theories seek to investigate what gets individuals to move towards what activities and to describe the characteristics of these activities (Pantziara&Philipou, 2015). Motivation is defined as an internal state that arouses, directs, and maintains behavior, but simply stated motivation is a reason of students' thinking in a given situation (Garut, 2011). Motivation may also be seen as a theoretical concept utilized to clarify human behaviour. It provides the motive for human beings to react and fulfill their needs (Gopalan, Bakar, Zulkifli, & Mat, 2017). The question of how to motivate students in the classroom has become a leading concern for teachers of all disciplines.

Addressing the issue of content, Iji and Omenka (2015) found that the responses of the subjects involved in their study showed poor agreement in the classifications of the mathematics concepts in algebra, number and numeration, geometry, trigonometry and statistics. The high rate of failure in public examination in Nigeria remains a huge problem to researchers, teachers and indeed all stakeholders in education. Studies have identified factors responsible for the high rates of failure to include among others, students' negative attitude to the subject, lack of qualified teachers, inadequacy of teachers, lack of necessary learning skills, specialized language of the subject and inadequate and unsuitable textbooks. Also, it has been established that there is a significant relationship between teachers' method of teaching, teachers' attitude and students' achievement in mathematics (Avong, 2013; Daso, 2013).

The variation teaching strategy which is based on the variation theory is one of those novel teaching strategies employed by mathematics teachers. Variation theory is a theory of learning and experience that

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explains how a learner might come to see, understand, or experience a given phenomenon in a certain way and why two students sitting in the same class might come to understand a concept differently. It is a necessary component in teaching in order for students to notice what is to be learned (Bussey, Orgill&Crippen, 2012; Learning Project Team of HKU, 2011; Kullberg, Kempe&Marton, 2017).

Lai and Murray (2013) opine that procedural variation is derived from three forms of problem solving in algebra: Varying a problem; extending the original problem by varying the conditions, changing the results and generalization.Partitive Variation Teaching Strategy (PVTS) is when a part or parts of a particular problem are held constant, while other parts are changed. For example, given y = 2, evaluate:

a. 5y
b. 5y – 3
c. $5y^2 – 3$
d. $5y^2)^2 – 3$

It can be used to address individual differences in the classroom by allowing students to draw upon their personal experiences and apply them in their learning (Cheng, 2016).Random Variation Teaching Strategy (RVTS) on the other hand refers to the teaching of algebra, in which cases, entire set of problems come with a varied structures.For example, given that y = 2, evaluate:

a. x + 5
b. 4x – 9
c. $3x^2 + 7$
d. 9 (x – 2)

The object of learning for both examples is to evaluate algebraic expressions by substituting letters for numbers. A mathematics pedagogy that is rooted in variation is one that purposefully provides

learners with the means to experience variation through strategically designed activities in order to create a mathematically rich learning environment that allows learners to discern the object of learning. It is defined by its critical features that must be discerned in order to constitute the meaning aimed for. So as a pedagogic approach, a pattern of variation is a useful tool for structuring teaching to make the learning of the object of learning possible (Mhlolo, 2013). This ultimately leads to improved performances as evidenced by a number of studies.

The study by Ifelunni, Ugwu, Aneke, Ibiam, Ngwoke, Ezema, Charles, Oraelosi, & Ede (2019) investigated motivation as a determinant of academic achievement of primary school pupils in Mathematics in South-East, Nigeria. A population of 357,115 primary 5 pupils in all the 5,378 public primary schools in South-East, Nigeria was used for the study. The sample for the study comprised 400 primary 5 pupils. The findings of the study revealed, among others that there is a significant correlation between intrinsic motivation and primary school pupil's academic achievement. Liu (2018) carried out a study on "Potential reciprocal relationship between motivation and achievement: A longitudinal study". It included students from 1,052 high schools across the United States. Motivation had a greater influence on follow-up mathematics achievement (0.079, $p<0.001$). Jing, Tarmizi, Bakar and Aralas (2017) investigated the effect of utilizing Variation Theory Based Strategy on students' algebraic achievement and motivation in learning algebra. The study used quasi-experimental non-equivalent control group research design and involved 56 Form Two (Secondary Two) students in two classes (28 in experimental group, 28 in control group) in Malaysia. Result from analysis of covariance (ANCOVA) indicated that the experimental group students achieved significantly better test scores than the control group. In addition, result of Multivariate Analysis of Variance (MANOVA) also showed evidences of significant effect of VTBS on experimental students' overall motivation. These results suggested the utilization of VTBS would improve students' learning in algebra. Effect of integrated curriculum delivery strategy on

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secondary school students' achievement and retention in Algebra in Benue state was experimented by Anyor and Iji (2010). The population comprised 1,368 Senior Secondary 1 students out of which 149 were purposively sampled. The study found among other things that Integrated Curriculum Delivery Strategy (ICDS) enhanced students' achievement and retention in algebra taught during the course of the study. The ICDS highlighted the importance of creativity which is akin to the partitive variation teaching strategy, in the teaching and learning of algebra in schools. These empirical studies provided gaps and conclusions which were further investigated in the present study.

The following research questions guided the study:

i. What is the effect of the PVTS on the mean motivation ratings of Basic 5 pupils as compared to those taught using the RVTS?
ii. What is the effect of the PVTS on the mean algebraic performance of Basic 5pupils as compared to those taught using RVTS?

Two corresponding null hypotheses were formulated and tested at 0.05 level of significance:

i. There is no significant effect of the PVTS on the mean motivation ratings of Basic 5 pupils as compared to those taught using the RVTS.
ii. There is no significant effect of the PVTS on the mean algebraic performance of Basic 5pupils as compared to those taught using RVTS.

MATERIAL AND METHODS

The quasi experimental, pretest-posttest, control group design is adopted for the study. This design is seen as suitable due to the inability to manipulate and randomize the respondents who were primary school pupils studying in Basic Five. Denga (2017) posited that quasi-experimental studies are conducted under conditions that do not permit control, manipulation of variables or random selection. Random assignment can be achieved but the intact groups coupled with administrative constraints (random selection may lead to a disruption

of school organization and classes) do not allow randomization, control or manipulation. It is an investigation of the effectiveness of a teaching method where random selection of subjects is not possible being a good example, in this study, the Partitive Variation Teaching Strategy.

The area of study is Benue Education Zone B, also called Benue North West Senatorial Zone. The population comprised20,895 pupils from 1,804 primary schools in Zone B education zone of Benue state (SUBEB, Makurdi, 2019). The sample for this study was 254 pupils. There was a total of 113 pupils (54 male and 59 female) in the experimental group, while the control group had 141 pupils (77 male and 64 female).

Procedure Methodology

The study made use of 2 instruments: Algebra Motivation Questionnaire (AMQ) and the Algebra Performance Test (APT). The AMQ was a 30-item motivation questionnaire containing both pleasant (positively skewed) and unpleasant (negatively skewed) items, designed by the researcher. The Algebra Performance Test (APT) was a 20-item test set by the researcher. There were 2 sets of lesson plans for the research in each sub-topic treated, one for the Partitive Variation Teaching Strategy (experimental group) and the other for the Random Variation Teaching Strategy (control group). Some lesson plans were for a period of 1 hour, while others were for 30 minutes.

Statistical Analysis

The means and standard deviations of the variables studied were used to answer the research questions. The Analysis of Covariance (ANCOVA) was used to test the hypotheses relating to students' algebraic performance. Motivation on the other hand, was analysed using Multivariate Analysis of Covariance (MANCOVA) with data obtained from the AMQ. Both hypotheses were tested at 0.05 level of significance.

RESULT

The data is presented according to the objectives of the study. This is done by placing data for a research questions first and followed immediately by the corresponding hypothesis.

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Research question one: What is the effect of PVTS on the mean ratings of Basic 5 pupils' motivation as compared to those taught using the RVTS?

Table 1:Descriptive statistics for mean motivation ratings in the experimental and control groups

		Experimental (N = 113)		Control (N = 141)	
	Motivation	Mean	Std. Dev.	Mean	Std. Dev.
Posttest	Attention	3.62	0.25	2.26	0.38
	Relevance	3.29	0.34	2.73	0.38
	Confidence	3.04	0.42	2.85	0.43
	Satisfaction	3.10	0.44	2.86	0.37
	Interest	3.22	0.35	2.71	0.41
	Total	**3.26**	**0.42**	**2.68**	**0.45**
Pretest	Attention	2.49	0.37	2.36	0.32
	Relevance	2.84	0.35	2.56	0.30
	Confidence	2.94	0.43	2.90	0.42
	Satisfaction	2.91	0.42	2.83	0.43
	Interest	2.94	0.41	2.67	0.37
	Total	**2.83**	**0.43**	**2.66**	**0.42**

Results in *Table 1* display the means and standard deviations of the responses with respect to motivation of pupils in the experimental and control groups. It reveals that in the experimental group, the pupils consistently improved individually and in the total means (2.83 to 3.26) while the standard deviation got smaller from 0.43 to 0.42 which shows an improvement in the data distribution across the sub-scales of attention, relevance, confidence, satisfaction and interest. Results in the table also illustrate the means and standard deviations of the responses with respect to motivation of pupils in the control group. It reveals that the pupils appear to have responded in a similar fashion individually and in the total means (2.66 and 2.68). The standard deviations were 0.42 and 0.45 across the sub-scales of attention, relevance, confidence, satisfaction and interest. The standard deviations in both groups showed elements of homogeneity in their responses.

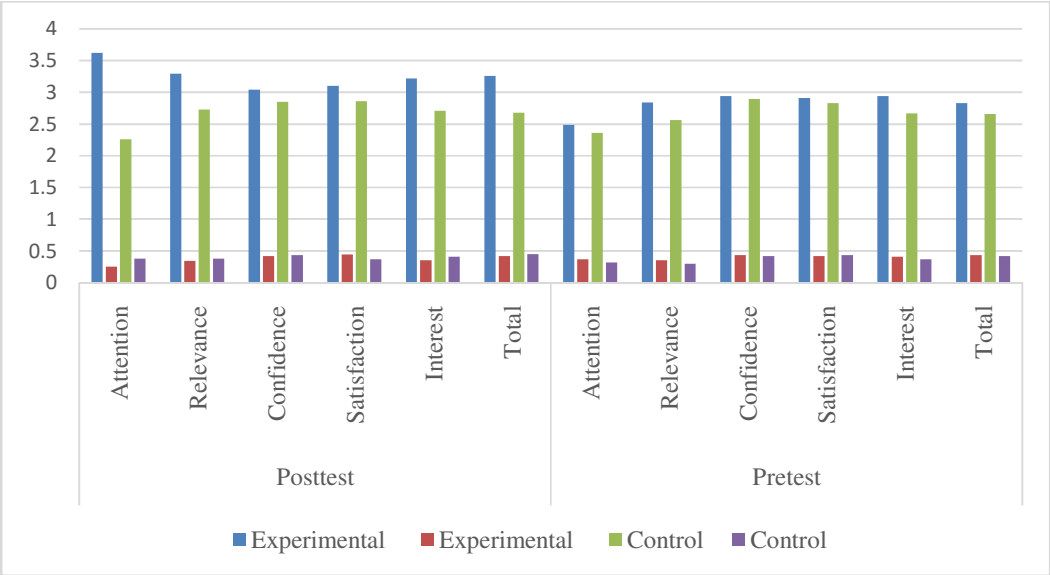

Figure 1: Bar chart for mean motivation ratings in the experimental and control groups

The figure is a pictorial representation of Table 1. It displays the means and standard deviations of the experimental group in blue and red respectively, while the means and standard deviations of the control group are displayed in green and purple respectively.

Table 2: Descriptive statistics for the motivation responses of pupils in the four sub-groups

	Group	Mean	Std. Deviation	N
Posttest	Experimental1	3.26	0.22	71
	Experimental2	3.25	0.19	42
	Control1	2.68	0.27	34
	Control2	2.68	0.27	107
Pretest	Experimental1	2.81	0.28	71
	Experimental2	2.86	0.24	42
	Control1	2.67	0.25	34
	Control2	2.66	0.24	107

Results in Table 2 show that the mean responses of the pupils in Experimental Group One increased from 2.81 in the pretest to 3.26 in the posttest, with standard deviations of 0.28 and 0.22 respectively. In the Experimental Group Two, the pupils had a mean response on 2.86 in the pretest and increased to 3.25 in the posttest, with standard deviations of 0.24 and 0.19 respectively. In the Control Group One, the

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pupils had mean response of 2.67 in the pretest and 2.68 in the posttest with standard deviations of 0.25 and 0.27 respectively. The mean response of the pupils in Control Group Two was 2.66 with a standard deviation of 0.24, in the pretest and mean of 2.68 and standard deviation of 0.27 in the posttest, this demonstrated an almost static response in the control group.

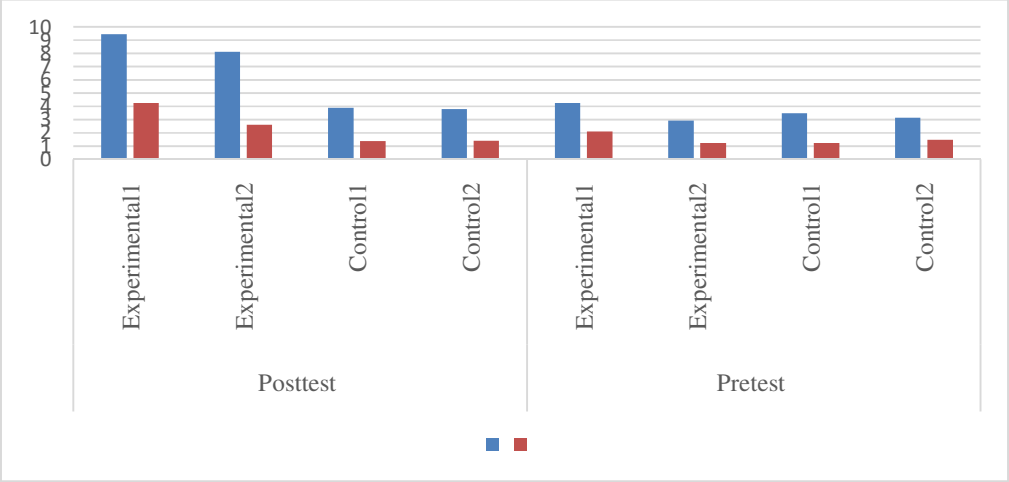

Figure 2: Bar chart for the motivation responses of pupils in the four sub-groups

The bar chart in *Figure 2* illustrates the mean and standard deviations of the mean motivation ratings of the pupils in the experimental and control groups as individual groups.

Table 3:Summary descriptive statistics for mean motivation ratings according to the experimental and control groups

		Pretest		Posttest		
Group	N	Mean	S.D.	Mean	S.D.	Mean Gain
Experimental	113	2.83	0.43	3.26	0.42	0.43
Control	141	2.66	0.42	2.68	0.45	0.02
Mean difference		**0.17**		**0.58**		**0.41**

The experimental and control groups had a mean motivation rating of 2.83 and 2.66 in the pretest respectively with a mean difference of 0.17 in favour of the experimental group. The data also showed that the pupils in the two groups had corresponding means of 3.26 and 2.68 in the posttest, this gave a mean difference of 0.58, also in favour of the

experimental group. There was a mean gain of 0.43 for the experimental group to the control group's mean gain of 0.02, which gave rise to a mean gain difference between the groups of 0.41. The standard deviation for the experimental group (0.42) was smaller than those of the control group (0.45) in the posttest; this indicates that the responses of the pupils in the experimental group were more homogenous than those in the control group. This depicts a positive effect of the PVTS motivation of pupils in learning algebra among the sample of pupils, to answer the research question.

Hypothesis one: There is no significant effect of the PVTS on the mean motivation ratings of Basic 5 pupils as compared to those taught using the RVTS

Table 4:Summary of multivariate tests for mean motivation ratings between the experimental and control groups

Effect		Value	F	Hypothesis df	Error df	Sig.
Groups	Pillai's Trace	0.59	33.94	6	492	0.00
	Wilks' Lambda	**0.42**	**44.64**	**6**	**490**	**0.00**
	Hotelling's Trace	1.38	56.26	6	488	0.00
	Roy's Largest Root	1.38	112.93	3	246	0.00

The data is interpreted using Wilks' Lambda, the recommended measure (Lund & Lund, 2020) for a multivariate statistic (MANCOVA) for the study. Data in *Table 4* shows that there is a statistically significant difference $F(6, 490) = 44.64$ and $p = 0.00 < 0.05$ in the mean motivation rating of the respondents. The research hypothesis one is therefore rejected, which implies that the mean motivation ratings of pupils taught using the PVTS differ significantly from those taught using the RVTS. This suggests that the pupils showed greater attention, relevance, confidence, satisfaction and interest in the learning of algebra when taught using the intervention strategy.

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Research question two: What is the effect of the PVTS on the mean score of Basic 5 pupils' algebraic performance as compared to those exposed to RVTS?

Table 5:Descriptive statistics showing the mean scores at APT in the experimental and control groups in terms of the four sub-groups

	Group	Mean	Std. Deviation	N
Posttest	Experimental1	18.99	7.74	71
	Experimental2	21.05	9.95	42
	Control1	9.82	3.79	34
	Control2	9.81	3.69	107
Pretest	Experimental1	11.10	5.70	71
	Experimental2	8.86	2.58	42
	Control1	8.38	3.04	34
	Control2	7.48	3.54	107

Results in Table 5 reveal the means and standard deviations of the 4 sub-groups in terms of the algebra performance test. The Experimental Group One had a mean of 11.10 in the pretest with a standard deviation of 5.70 and a mean of 18.99 and standard deviation of 7.74. The Experimental Group Two had a mean of 8.86 and 21.05 in the pretest and posttest respectively, with standard deviations of 2.58 and 9.45. The Control Group One had a mean of 8.38 in the pretest and 9.82 in the posttest, with standard deviations of 3.04 and 3.79 respectively. The Control Group Two had a mean of 7.48 in the pretest and 9.81 in the posttest, with corresponding standard deviations of 3.54 and 3.69 respectively. On the whole, the two groups demonstrated similar data characteristics going by their standard deviations. However, there appears to be a disproportionate data behaviour in Experimental Group Two, where the standard deviation in the posttest appears abnormal to the other results in relation to the mean and total number of respondents.

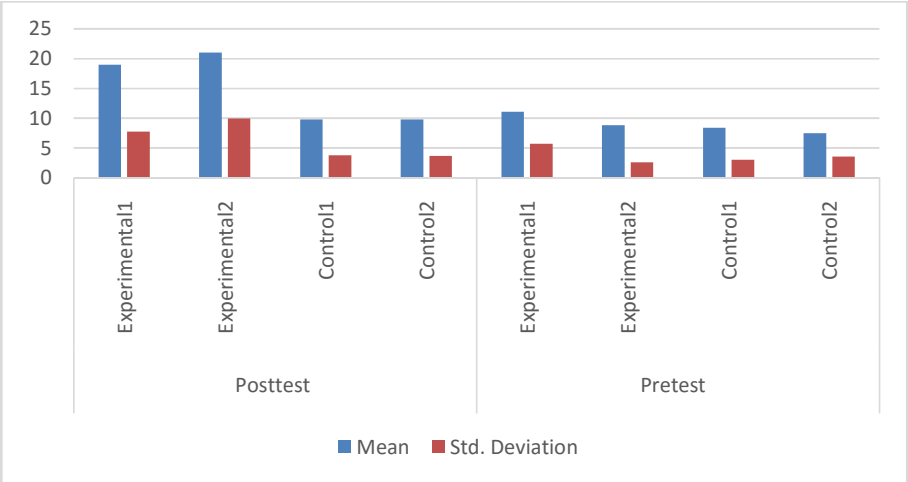

Figure 3: Bar chart showing the mean scores at APT in the experimental and control groups in terms of the four sub-groups

The means in blue and standard deviations in red illustrate the scores of pupils in the groups with respect to the pretest and posttest performance.

Table 6: Summary descriptive statistics showing the mean difference between the experimental and control group at APT

		Pretest		Posttest		
Group	N	Mean	S.D.	Mean	S.D.	Mean Gain
Experimental	113	9.98	4.14	20.02	8.85	10.04
Control	141	7.93	3.29	9.82	3.74	1.89
Mean difference		**2.05**		**10.20**		**8.15**

Results in *Table 6* shows that pupils in the experimental group had a mean of 9.98 and 20.02 and standard deviation of 4.14 and 8.85 in the pretest and posttest respectively; this gives a mean gain of 10.04 for the experimental group. The control group on the other hand had a mean performance score of 7.93 and 9.82 with standard deviations of 3.29 and 3.74 in the pretest and posttest respectively with a mean gain of 1.89. There was a mean difference of 2.05 and 10.20 in the pretest and posttest, and 8.15 in the mean gain. The standard deviations of the two groups are an indication that the data sets share similar traits, because they fall within the same side and partition of the normal curve. To answer the research question, the PVTS appears to have caused an increased algebraic performance in the APT by pupils in the

experimental group as compared to pupils that were taught using the RVTS.

Hypothesis two: The PVTS has no significant effect on Basic 5 pupils' algebra performance mean score as compared to those taught using the RVTS.

Table 7: Summary tests of between-subjects (experimental and control groups) effects with respect to the APT using posttest as the dependent variable

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7433.87	8	929.23	25.18	0.00
Intercept	4701.44	1	4701.44	127.42	0.00
APTpretest	939.46	1	939.46	25.46	0.00
Gender	54.74	1	54.74	1.48	0.22
APT	4773.41	3	1591.14	43.12	0.00
Gender * APT	157.16	3	52.39	1.42	0.24
Error	9039.95	245	36.90		
Total	67952.00	254			
Corrected Total	16473.83	253			

The analysis shown in *Table 7* reveal that there was a statistically significant effect, where $F(3, 245) = 43.12$ and $P = 0.00 < 0.05$ of the PVTS when compared to the RVTS in the mean performance scores of pupils. The null hypothesis is rejected which implies that the PVTS has a significant effect on Basic 5 pupils' algebra performance mean score as compared to those taught using the RVTS.

DISCUSSION

This study found a significant difference in the mean motivation ratings of pupils in the experimental group and the control group in favour of the experimental group which agrees with Jing, Tarmizi, Bakar and Aralas (2017).The findings also agree withYakubu (2017) who found that pupils with mathematics learning challenge in the treatment group showed higher motivation than pupils in the control group. There were evidences of significant effect of the partitive variation theory-based strategy on experimental students' overall motivation. This indicated that the partitive variation teaching strategy may be capable of triggering both the intrinsic and extrinsic motivation of pupils in the

middle basic level of education in Benue state, Nigeria. This was made more consistent by the more improved mean motivation ratings in the 5 subscales of attention, relevance, comprehension, satisfaction and interest, which the pupils in the experimental group consistent had higher mean responses.

There was statistically significant difference in the performance of students between the experimental group and the control group, which agrees with Anyor and Iji (2010) as well as Jing, Tarmizi, Bakar and Aralas (2017). The positive interaction of organizational culture, education in this case, and human resource management (teaching) would result in self-esteem and self-actualization. Generally, it is agreed that dispositions such as motivation, curiosity and perseverance can be recognised when students persist at difficult tasks, take risks and exhibit open mindedness (Al-Shara, 2015). The findings of this study also agree withthose of Liu (2018) as well as Ifelunni, Ugwu, Aneke, Ibiam, Ngwoke, Ezema, Charles, Oraelosi, and Ede (2019) that there is a significant influence of motivation or that there is a potential reciprocal relationship between motivation and academic performance of students. García, Rodríguez, Betts, Areces and González-Castro (2016) stated that Mathematics enjoyment or satisfaction positively predicted mathematics achievement as has been confirmed in this study. Higher motivation ratings which may be due to the partitive variation teaching strategy predicatedbetter algebraic performances among Basic school learners.

CONCLUSION

This study concluded that pupils in the experimental group significantly showed higher motivation ratings and consistently outperformed those in the control group in the algebra performance test. The study further concluded that the partitive variation teaching strategy may be useful for the improvement of algebra teaching and learning in Middle Basic (Basic 5) level of education in Benue state, which may be replicated in other locations.

REFERENCES

Jing, T. J., Tarmizi, R. A., Bakar, K. A., &Aralas, D. (2017). The adoption of variation theory in the classroom: effect on students' algebraic achievement and motivation to learn. *Electronic Journal of Research in Educational Psychology*, 15(2), 307-325

Pantziara, M. &Philippou, G. N. (2015). Students' motivation in the mathematics classroom. Revealing causes and consequences. *International Journal of Science and Mathematics Education*, 13(2)

Garut, P. (2011). *Motivation in learning mathematics.* Retrieved online from https://p4mristkipgarut.wordpress.com/2011/05/03/motivation-in-learning-mathematics/ on 12th February, 2018

Gopalan, V., Bakar, J. A. A., Zulkifli, A. N., Alwi, A. & Mat, R. C. (2017). *A review of the motivation theories in learning*. Malaysia: AIP Publishing

Iji, C. O. &Omenka, J. E (2015). Mathematics teachers' perception of difficult concepts in secondary school mathematics curriculum in Benue state, Nigeria. *Asia Pacific Journal of Education, Arts and Sciences*, 2(1)

Avong, H. N. (2013). Poor performance in mathematics among senior secondary school students in Kaduna state: what's to blame? *JORIND,* 11(2).

Daso, P. O. (2013). Teacher variables and senior secondary students' achievement in mathematics in Rivers state, Nigeria. *European Scientific Journal,* 9(10), 1857 – 7881

Bussey, T. J., Orgill, M. &Crippen, K. J. (2013). *Variation theory: A theory of learning and a useful theoretical framework for chemical education research.* The Royal Society of Chemistry,University of Florida, School of Teaching and Learning, Gainesville, USA

Learning Project Team of HKU (2011). What teachers should know about learning theories. Retrieved online from https://kb.edu.hku.hk/approaches_variation_theory/ on 22nd March, 2018

Jerome, N. (2013)Application of the Maslow's hierarchy of need theory;impacts and implications on organizational culture, human resource and employee's performance. International Journal of Business and Management Invention, 2(3), 39-48

Kullberg, A., Kempe, U. R. &Marton, F. (2017). What is made possible to learn when using the variation theory of learning in teaching mathematics? *ZDM Mathematics Education*, 49:559–569

Lai, M. Y. & Murray, S. (2013). Teaching with Procedural Variation: A Chinese Way of Promoting Deep Understanding of Mathematics. Retrieved online from www.researchoutput.csu.edu

Cheng, E. W. L (2016). Learning through the Variation Theory: A Case Study. *International Journal of Teaching and Learning in Higher Education*, 28(2), 283-292

Mhlolo, M. (2013). The merits of teaching mathematics with variation. *Pythagoras*, 34(2), Art. #233, 8 pages. http://dx.doi.org/10.4102/pythagoras.34i2.233

Anyor, J. W. &Iji, C. O. (2010). Effect of integrated curriculum delivery strategy on secondary school students' achievement and retention in Algebra in Benue state. *Abacus, journal of the Mathematical Association of Nigeria (MAN)*, 39(1), 83-96

Denga, D. I. (2017). *An introduction to research methods and statistics in education and social studies (4th).*Calabar: Clearlines Publications Limited

Lund, A. & Lund, M. (2020). *Two-way ANCOVA in SPSS.* Retrieved online from www.statistics.laerd.com/spss-tutorials/two-way-ancova-using-spss-statistics.php

Yakubu, I. W. (2017). *Effect of inclusion instructional strategy on motivation and achievement of Middle Basic pupils with mathematics learning challenge in Benue state.* A thesis in the department of Curriculum and Teaching, Benue state University, Makurdi

Mata, M. L., Monteiro, V. &Peixoto, F. (2012). Attitudes towards mathematics: Effects of individual, motivational, and social support factors. *ChildDevelopment Research, Volume 2012, Article ID 876028*, 10 pages

Al-Shara, I. (2015). Learning and teaching between enjoyment and boredom as realized by the students: a survey from the educational field. *European Scientific Journal* edition, 11(19), 146-168

Liu, Y. &Hou, S. (2018). Potential reciprocal relationship between motivation and achievement: A longitudinal study. *School Psychology International*, 3(2), 38–55

Ifelunni, C. O., Ugwu, G. C., Aneke, A. O., Ibiam, J. U., Ngwoke, A. N., Ezema, V. S., Charles A. Oraelosi, C. A. & Ede, M. (2019). Motivation as a Differential Predictor of Mathematics Achievement of Pupils in South-East, Nigeria. *Journal of Engineering and Applied Sciences, 14: 5345-5350*

García, T., Rodríguez, C., Betts, L., Areces, D., & González-Castro, P. (2016). How affective-motivational variables and approaches to learning relate to mathematics achievement in upper elementary levels. *Learning and Individual Differences*, 49, 25-31.

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ANALYSIS OF ERRORS IN COMPLETING SQUARE WHEN SECONDARY SCHOOL STUDENTS SOLVE QUADRATIC EQUATION BY NEWMAN ERROR ANALYSIS PROCEDURE IN NASARAWA STATE

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ABSTRACT

The purpose of this study was to diagnose, using the Newman error analysis model. The error committed when students solve quadratic equation using completing square method. The target population was all SS3 students in Nasarawa State public schools. Three research questions and three hypotheses were answered and tested respectively. Survey design was used for the study. Data collected was analysed using student t-test. The result of the findings showed that all the students committed errors at various stages of Newman model and there is no significance difference in the means of errors committed by SS3 students that solved quadratic equation using completing square method.

INTRODUCTION

The importance given to mathematics in the curriculum from primary to the secondary level reflects the role played by mathematics in contemporary society. It is in understanding of this that many countries now resort to making comprehensive and well programmed efforts towards effective teaching and learning of science and mathematics at all levels of the educational system through the development and implementation of improved programmes and projects (Azuka, 2001). In most schools in Nigeria for example, the study of mathematics is made mandatory for all students. In order to secure admission for most courses at higher levels of education, a credit pass in mathematics is a pre-requisite. In spite of importance of mathematics in human existence, students still perform poorly in the subject. Musa (2014) stressed that West African Examination Council (WAEC) results in mathematics between 2004 and 2013 attest to the candidates' poor performance. In this period, the percentage credit pass and above in mathematics at the Senior Secondary Certificate Examination (SSCE) level ranges about 40% pass. The West Africa Examination Council

(WAEC) Chief Examiners Report consistently reported lack of skill in answering almost all the questions asked in general mathematics. The most affected areas include, geometry of 3-dimensional problems, algebraic expression (quadratic equation) and words problems in equations, statistics and percentage errors to mention a few. In specific terms the examiners reported students' weaknesses in quadratic equation. Some areas of the syllabus that were also reported to be poorly attempted by candidates were the reading and drawing of quadratic graph among others. The weakness is also evident in the Chief Examiners' reports of WASSCE 2012, 2013, 2015, 2016 and 2018.In view of these general weak performances of students in mathematics, efforts are being made every now and then by mathematics educators at various quarter to bring mathematics teaching and learning meaningful. This is observed in the trends of workshops for teachers of mathematics and different research works in areas of teaching, student achievement in mathematics, attitude of students towards the subject and strategies to improve on the teaching and learning of mathematics. Learners are evaluated thereof on the way they conceive the concepts in mathematics and the quality of teaching. This will help to reveal learner errors and misconceptions (Riccomini, 2005). According to Riccomini, Mathematics teachers do not treat learner errors committed when solving mathematical problems seriously. He also said teachers do not have courage and patience to investigate learners' errors and problems experienced in solving mathematical problems.

Error can be defined here as a way of doing a thing wrongly. Reviewing the research method on errors, specifically, classifying students' errors based on the step of solving problems or the sources of difficulties in solving problems. Students correctly follow wrong algorithms, which is contrary to many teachers views that students wrongly follow an algorithm. This study focuses on where the error originated, which is linked between conceptual and procedural knowledge. One of the main methods used to analyze student's errors is to classify them into certain categorization based on analysis of students' mistakes. The errors are classified in terms of Language difficulties, difficulties in the processing

iconic and visual representation of mathematical knowledge, deficiency in the requisite skill, facts, and concepts; for example, student may forget or be unable to recall related information in solving problems, incorrect association rigidity; that is negative transfer caused by decoding and encoding information and application of irrelevant rules or strategies. Titus (2016) also used the classifying method but based his own on the model of problem solving (Polyer). He thought that Students errors may be due to deficiency in one or more of the above steps.

Analysis of error is the ability to establish the existence of errors in a computation. There are many factors that help students to turn up at a correct result while solving mathematical problems. The method is based on the fact that in the process of problem solving there are two major types of hurdles that hinder students from arriving at correct answers. They are; troubles in reading fluency and abstract understanding that helps reading and understanding meaning of problems. The other one is trouble of processing mathematical problems that consist of transformation, process skill, and encoding results. It is important to find where students commit such errors and continue to repeat them.
Studies have been conducted over years to determine the predictor of mathematics achievement among various groups of individuals. Some of the predictions are, socio-economic status of students, teaching methods teachers use, gender and environmental factors of students among others (Owolabi and Adejoke, 2014; Adeyinka and Kaino, 2014). One variable that has over the years, received considerable attention in many studies on science achievement in general and mathematics achievement in particular is gender. According to Owolabi and Adejoke (2014) studies conducted among middle and high school students show a significant gender effect favoring males in overall sciences and mathematic achievement. They also said in another study that boys outperform girls in science but in reading and writing, girls had the advantage. Abubakar and Oguguo (2011) study show no significant difference in gender achievement in relation to Number and

Numeration, Algebraic process and statistics. However, in some studies, both male and female perform at par having applied certain strategies (Adeleke, 2007).

Another variable which is of interest in this study is school location. There are different school locations in Nasarawa state which include urban, semi-urban rural or remote villages. The results of some studies outside the shores of Nigeria have shown that location is a variable to consider on students' achievement, example is Indonesia, Jambi province. Effandi and Siti (2010) attest that students in rural schools perform poorly in mathematics at the point of comprehension, given that the effect of mother tongue or bilingual conflict is prominent. The urban schools more errors are committed at the process skill and transformation stage.

One other factor the researcher considered is the student academic orientation (Science/arts). The orientation of the students may or may not narrow their understanding of specific concepts and will not be able to engage them in problem solving. Students who do not have background knowledge in mathematics usually display numerous errors in solving mathematical problems and this therefore results in most students grappling with quadratic equations (Sello, 2014). If a research could characterize students learning difficulties, it would be possible to design effective instruments to enhance students learning. The research on student's errors is a way to provide such support for both teachers and students.Li (2006), pointed out one way of trying to find out what makes algebra difficult is to identify the kind of errors students commit. There was also need to classify the errors based on the steps of solving problems. He reported that Radatz first classified students' errors in terms of language difficulties, mathematics is like a foreign language for students who needs to know and understand mathematical concepts, symbol, and vocabulary. Misunderstanding the logic for mathematics language could cause students error at the beginning of problem solving, difficulties in processing the representation of mathematical knowledge, like of requisite skills, knowledge, and concepts, poor associations or rigidity; that is, wrong transfer caused by decoding and encoding information and application of irrelevant rules or strategies.

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Anne Newman (1980) than used the classifying method but based her model on problem solving.

The model of the sequence of steps in problem solving: reading and comprehension, transformation, process skill, and encoding to identify students' possible errors. She thought that student's error may be due to deficiency in one or several of the above steps. This is what is today referred to as Newman error analysis procedure (Newman Model) which the researcher will adopt to diagnose errors students commit by senior secondary school three when solving quadratic equation by completing square method.

STATEMENT OF THE PROBLEM

In SSCE mathematics examination, students have presented difficulties in solving equations. The Chief Examiner's Report of 2011 to 2017 all emphasized that students are weak in algebraic process; Quadratic equation is one topic that every year WASSCE features to test the concept among students and also to test their procedural understanding of quadratic equations. These mistakes lower students' achievement in SSCE Mathematics achievement it is therefore important to identify the types of errors students commit and where they commit them.The Newman Model; Newman Error Analysis Procedure has been found useful for analyzing students' errors when solving quadratic equations since it takes them through the steps needed to reach the solution. The focus of this study therefore was to analysis the errors committed when senior secondary school students solve quadratic equations by completing square method using Newman error analysis procedure.

OBJECTIVES OF THE STUDY

The objectives of this study were using Newman Error Analysis procedure;

1. compare the means and standard deviations of errors committed by male and female senior secondary school (SS3) students' when solving quadratic equation by completing square method

2. established the means and standard deviations of errors committed by urban and rural senior secondary school (SS3) students committed when solving quadratic equation using method of completing square
3. compare the means and standard deviation of errors committed by Science and Art senior secondary school (SS3) students' when solving quadratic equations using the method of completing square.

RESEARCH QUESTIONS

The following research questions guided the study.

Using Newman error analysis Procedure;

1. what are the means and standard deviations of errors committed by male and female senior secondary school three (SS3) students' when solving quadratic equations by completing square method?
2. what are the mean and standard deviations of errors committed by senior secondary school three (SS3) students' in the urban and rural areas when solving quadratic equation using completing square?
3. what are the mean and standard deviations of errors committed by science and arts senior secondary school three (SS3) students' when solving quadratic equation by completing square mwthod?

STATEMENT OF HYPOTHESES

The following null hypotheses were tested at 0.05 level of significance.

Using Newman error analysis procedures;

Ho_1: There is no significant difference in the mean scores of errors committed by male and female senior secondary school students' when solving quadratic equations by completing square method

Ho_2: There is no significant difference in the mean scores of errors committed by urban and rural senior secondary school students' when solving quadratic equation using completing square method

Ho_3: There is no significant difference in the mean scores of errors committed by Science and Art senior secondary school students' when solving quadratic equations using completing square method

RESEARCH METHODOLOGY

The research designs used for the study was survey research designs.This design involved the collection of data with a short span of time from randomly selected sample of the target population. The cross-sectional survey design also called parallel-sample design was used for the study.

Population

The population of the study comprised all senior secondary school three (SS3) students in public senior secondary schools in Nasarawa State.

Sample and Sampling Procedure

One senatorial district was randomly selected for the survey. Multi-stratified random sampling procedure was used to select the schools for the study in terms of gender, school location and background

Method of Data Collection; Instrumentation

Data were collected using, Quadratic Equation Diagnostic Test.

Quadratic Equation Diagnostic Test (QEDT):

The researcher selected the items of this test from past SSCE questions papers and work examples from text books that are recommended by WAEC in the syllabus. This was attempted by all the students in the sampled schools. Test was administered and scripts were returned and marked. The scores recorded with respect to the Newman error analysis procedure stages and was tested.

Techniques for Data Analysis

The research questions were answered using means and standard deviation of scores for errors committed by SS3 students while the Hypotheses were tested using student independent t-test at $\alpha \leq 0.05$.

Results and Data Analysis

Research Question 2; What are the means and standard deviations of error committed by male and female SS3 students that solve quadratic equations using completing square method?

Table 1: Means and Standard Deviations of Error Committed by Male and Female Students that Solve Quadratic Equation Using Completing Square Method

Variables	Means	Standard Deviation	t-test
Male	1.612	0.209	0.095
Female	1.780	0.227	

Table 1 shows the means and standard deviations of male and female SS3 students that solve quadratic equation using completing square method. The mean scores for male students was 1.612and standard deviation was 0.209. The mean scores for the female students was 1.780 and standard deviation was 0.227

Research Question 3; What are the means and standard deviations of error committed by urban and rural SS3 students that solve quadratic equations using completing square method?

Table2: Means and Standard Deviations of Error Committed by Urban and Rural Students that Solve Quadratic Equation Using Completing Square Method

Variables	Means	Standard Deviation	t-test
Urban	1.600	1.191	0.020
Rural	1.704	0.174	

Table 2 shows the means and standard deviations of urban and rural SS3 students that solve quadratic equation using completing square method. The mean scores for urban students was 1.600and standard deviation was 1191. The mean scores for the rural students was 1.704and standard deviation was 0.174.

Research Question 3; What are the means and standard deviations of error committed by science and art SS3 students that solve quadratic equations using completing square method?

Table3: Means and Standard Deviations of Error Committed by Science and Art Students that Solve Quadratic Equation Using Completing Square Method

Variables	Means	Standard Deviation	t-test

Science	1.640	0.244	0.898
Art	1.648	0.182	

Table3: shows the means and standard deviations of science and art SS3 students that solve quadratic equation using completing square method. The mean scores for urban students was 1.640and standard deviation was 0.244. The mean scores for the rural students was 1.648and standard deviation was 0.482.

Hypothesis1: There is no significant difference in the means score of errors committed by male and female SS3 students that solved quadratic equations by completing square.

Table1, presents the t-test analysis of errors committed by male and female SS3 students that solved quadratic equation by factorization methods. The t-test for difference of two means was 0.095. Therefore, as P = 0.095 is greater than α =0.05 (P=0.095>α =0.05). The difference was not significant at α<0.05 therefore we do not reject thenull hypothesis.

Hypothesis 2 There is no significant difference in the mean scores of errors committed by urban and rural SS3 students when solving quadratic equation by completing square.

Table2 presents the t-test result of errors committed by urban and rural SS3 students that solve quadratic equation by completing square method. The t-test difference of two mean was 0.020. It is observed that P = 0.020 is greater than α = 0.05 (since P = 0.020>α = 0.05). The difference between the means of error that urban and rural SS3 students committed when solving quadratic, equation by completing square is not significantly different at α<0.05 therefore we reject the hypothesis.

Hypothesis 3

There is no significant difference in the mean scores of errors committed by science and arts SS3 students when solving quadratic equation by completing square,Table 3 presents t-test analysis of errors committed by science and arts SS3 students that solve quadratic

equation by completing square method. The t-test for difference of two means was 0.898. It is observed that P = 0.898 is greater than α = 0.05 (P = 0.898>α 0.05). The difference between the means error that science and arts SS3 students committed when solving quadratic equation by completing square is not significantly different α<0.05. we therefore accept the hypothesis so stated.

DISCUSSION OF FINDINGS

The discussion was made on the bases of the research questions and the corresponding hypotheses stated and tested.The types of errors committed by students when solving quadratic equation using completing square by Newman Model reflects all the error types enumerated in the model. The most error type that the SS3 students committed was in the translation stage followed by the process skill, decoding, encoding and the comprehension stages. The difference between the errors type committed are however closely related. The presentation is in agreement with the findings of Effidini&siti (2010), Teoh (2010), and Nande (2013) that shows significant errors appearing at the transformation stage and the process skill the most.The result in the case of male and female table 1 shows that there were errors committed by both male and female students this agrees with previous researches (Bosire, Mondon&Barmoa 2008), who reported that irrespective of the schools, male respondent perform better than female. In regards to table 2, the mean score of errors committed by urban students when solving quadratic equation using completing square method was less than that of the rural students. This means the urban students committed less error than the rural students. The t-test was 0.020 which is greater than $\propto \leq 0.05$, since P = 0.020> 0.05, the hypothesis was rejected for the method of completing square. The findings here supported the finding in (Teoh,2010 and Shio, 2012). Even though the errors were more in different locations that is the rural pupils' errors were found mostly at comprehension and transformation stages while the urban students' errors were more at the process skill. However, in all, the rural students committed more errors than the urban students. Table3 shows that the mean score of errors committed by science students when solving quadratic equation by completing

square was less than that of the Arts students. This shows that science students committed less errors when solving quadratic equation by completing square. The t-test was 0.898, this is greater than $\propto \leq 0.05$. Therefore, since P = 0.898, $\geq \propto = 0.05$, the hypothesis was not accepted, indicating that the mean are not significantly different in completing squaremethod. This did not support Trance (2013), that science and engineering students achieve better in mathematics than other discipline

CONCLUSION

The results of thefindings showed that all the SS3 students presented difficulties at all stages of the Newman Model of Decoding, Comprehension, Transformation, Process kill and Encoding. That there is no significant difference in the means of SS3 students that solved quadratic equation by completing square gender, location and background. However, the means of urban and rural SS3 students that solve quadratic equation by completing square method are significantly different.

REFERENCES

Abubakar, R. B. &Oguguo, O. D, (2011). Age and Gender as predictors of Academic Achievement of College Mathematics and Science students. instructional conference on teaching, learning and change. *Institution Association for teaching and learning IATEL.*

Adeleke, M. A. (2007). Gender disparity in mathematical performance revisited: can training in problem solving bring difference between boys and girls? *Essays in Education, 21.*

Adeyinka, A. A, & Kaino, L. M. (2014). School Type, Parental Influence and Mathematics Attitudes-Achievement Relationship*: A Quantile Analysis. vol.1(2) p.23-28*

Airasian, P. W. & Walsh, M. E. (1997). Constructivism cautions. *KAPPAN. 78 (6), 444 – 449.*

Allan L. W. (2009). Diagnostic and Pedagogical Issues with mathematical word problems. *Brunei International Journal of Science and mathematics Education* 1 (1), 100 – 112.

Askew, M. (2003). Word problems: Cinderellas or wicked witches? In I. Thompson (Ed), *Enhancing primary mathematics teaching (pp. 78 – 85).* Berkshire, England: Open University Press.

Bosire,J., Mondoh, H., &Barmao, A. (2008). Effect of streaming by gender on students achievement in mathematics in secondary schools in Kenya. *South African Journal of Education* Volume 28:595-607.

Brown, J. S. &VanLehn, K. (1980). Repair theory: A generative theory of bugs in procedural skills. *Cognitive Science, 4, 379-426.*

Chung, I. (2004): A comparative assessment of constructivist and traditionalist approaches to establishing mathematical connections in learning multiplication education, *Mathematics Educational 125 (2) 271 – 278.*

Clarkson, P. C. & Campus, M. (1991), In Prakitipon, N. &Nakamura,S. (2006). Analysis of Mathematics Performance of Grade 5 Students in Thailand using Newman Procedure. *Journal of International Cooperation in Education 9(1), pp. 111-122.*

Cortes' A., Kavafian, N. (1999). Les Principles Quiguideint La Penseedans La Resolution des Equations. Petit X, Universite Joseph Fourier, Grenoble V. 51, pp. 47 – 73.

Countryman, J. (1992*). Writing to Learn Mathematics*. Portsmouth, N.H.: Heinemann.

Drapper, R. (2002). School Mathematics reforms, constructivism, and Literacy: A Case for literacy instruction in the reform-oriented math classroom *Journal of adolescent & adult literacy,* 45 (6) 520-534.

Duong, H.T. (2017). An Investigation of Errors Related to solving problems on percentages. *The International Journal of Engineering and Science (IJES)* Vol. 6, Issue 3 pg 5 – 9.

Effendi, Z. & Siti M .M. (2010). Analysis of students error in learning of quadratic equations. *International education studies, vol. 3. No. 3 105 – 110.*

Eniayeju P. A & Jibrin A.T. (2012). Issues in the Nigerian science and technology education Agenda: *Contemporary Issue in Education*.vol.1. p.87-101.

Elsa, E. & Richard, C. (2011). Procedural instructions, principles, and examples: How to structure instructions for procedural tasks to enhance performance, learning, and transfer. Human Factors and Economics Society.vol. 53 no. 6 pp.749-770.

Fosnot, C. T., and Dolk, M. (2001). *Young Mathematicians at Work*: constructing the number system, addition and subtraction. Portsmouth, NH: Heinemann press.

Gray, E. and Tall D. O. (2001). Relationship between embodied objects and symbolic precepts: an explanatory theory of success and failure in mathematics. *In Proceeding, 25th Conference of the Int. group for the psychology of mathematics education*.Dorderch, V. 12, pp 317 – 326.

Inch, S. (2002*). The accidental constructivist*; a mathematician's Discovery College teaching, 50(3) 111 – 114.

Koay, P.L., Chang, S.H. & Ghani, M. (2012). *Mathematics Content Knowledge of Low Attainers. In Kaur, B. & Ghani, M. (EDs), Low AttainerS in Primary Mathematics* Singapore: World Scientist press Pp 159 – 176.

Kulbir S. S. (2006). *The Teaching of Mathematics*; sterling publishers Ltd. New Delhi.

Larochelle, M., Bednarz, N. (1998*). Constructivism and Education*, Cambridge, Ny: Cambridge University Press.

Lee, T. Y. (2001). Problem solving in calculus (Unpublished postgraduate diploma dissertation, Nanyang Technological University, Singapore).

Lester, F.K. (1994). Musings about mathematics problem-solving research: 1970-1994. *Journal for Research in Mathematics Education*, 25(6), 660-675. Lester, F. K., & Kehle, P. E. (2003). *From Problem Solving to Modeling*: The evolution of thinking about research on complex mathematical activity. In R. Leash, and H. Doer (Eds.) Beyond constructivism: Models and modeling

perspectives on mathematics problem solving, learning and teaching (pp. 501-507). Mahwah, N.J.: Lawrence Erlbaum Associates, Publishers.

Li, X. (2006). Cognitive Analysis of Students Errors in and Misconceptions in Variables, and Functions. A Dissertation Submitted to the Office of Graduate Studies of Texas A&M University.

Lima, R .N. de. (2007). Equacoesalgebricas no ensinomedio: *Uma jornadaPorDiferentesmundos da matermatica*. Thesis, (Ph.D in mathematics education-pontificiauniversidadecatolica de Sa'o Paulo), Sao Paulo.

Lima, R. N. de &Tall, D. O. (2008). Procedural embodiment and magic in linear equations. *Educational Studies in Mathematics, 67(1), 3-18.*

Lu, O.C. (2015). Error Analysis for Arithmetic word problems. A case study of primary three students in one Singapore School. National Institute of Education, Singapore. Wanyang Walk, Singapore 637616.

Marinas, B., & Clements, M.A. (1990). Understanding the problem: A prerequisite to problem *solving* in mathematics. *Journal of Science and Mathematics Education in South East Asia*, 13 (10), 14-20.

Mewman, M. A. (1983*). Strategies for Diagnosis and Remediation*. Sydney; Harcourt, Brace Jovanovich.

Mu'awiya, H.U. & Muhammad, M.H. (2017). Analysis of student errors in learning of trigonometry among senior secondary school students in Zaria metropolis, Nigeria *IOSR Journal of Mathematics Vol. 13(2) pg 1 – 04.*

Mu'awiya, H.U. (2015). Analysis of problem-solving difficulties with quadratic equation among senior secondary schools students in Zaria, Nigeria. *ATBU Journal of Science, Technology and Education Vol.3 (3) pg 1 – 10.*

Musa D.C. (2014). Effect of laboratory Approach on junior secondary school students, achievement, interest and Retention in Mathematics in Keffi Education Zone, Nasarawa State. A Ph.D

Thesis submitted to school of post graduate studies University of Keffi.

Natcha, P., & Satoshi N. (2006). Analysis of mathematics performance of grade five students in Thailand using Newman procedure. CICE Hiroshima University, *Journal of InternationalCooperation in Education* VOL. 9, No 1, pp. 111-122.

Newman, M. A. (1977). An analysis of sixth-grade pupils' error on written mathematical task. *Victorian Institute for Educational Research Bulletin, 39, 31-43.*

Norasiah, A. (2002). Diagnosis jeniskesilapandalamhierarkiPembelajaran. [Error type diagnosis in learning simultaneous equation*]. Master of Education Research Project*. UniversitiKebangsaan Malaysia.

Norman, D.A. (1981). Categorization of action slips. *Psychological Review, 88, 1-15.*

Nzewi, U. N. (2003*). GenderIssues in Science and Technology Education for Sustainable U.B.E.* Federal College of Education Umunze Publication 232 – 238.

Odili, G. A. (2006) *Mathematics in Nigeria secondary schools; A teaching perspective*. Anachuna Educational Books. Ikeja, Lagos.

Okeke, E. A. C. (2001). *Women in science, technology and mathematics education in Nigeria 42nd Annual Conference proceedings of STAN*. Ibadan HEBN.

Okeke, E., Okwo, F. and Oreh, C. (1996). Enrolment trend and drop-out of boys in Nigeria (1993 – 96). UNICEF Commissioned Country Study.

Osafehinti, I. O. (1990). The university of mathematics*: Journal of Mathematical Association of Nigeria ABACUS* 20(1) Pp 48 – 56.

Owolabi J.& Adejoke E.O. (2014). Effect of Gender, Age and Mathematics Anxiety on College Students Achievement in Alagebra*American Journal of Education Research*, Vol. 2, No. 7: 474 – 476.

Ozlem, Y. and Rossi, H. (2002). Constructivist teaching as an effective learning approach. *Undergraduate Research Journal for the Human Science Volume* 7.

Payne, S. J. & Squibb, H.R. (1990). Algebra mal-rules and cognitive account of errors in cognitive science, Austin volume 14. Pp. 445 – 448.

Polya, G. (1973). *How to solve it: A new aspect of mathematical method*. Princeton, N.J. Princeton University Press.

Riccomini, P.J. (2005). Identification and remediation of systematic errors patterns in subtraction. *Learning disability quarterly, 28(3), 233-242.*

Richardson, V. (1997). Constructivist teaching and teacher education; Theory and practice. In V.Richardson (ed), constructivist Teacher educational; Building New understandings (pp. 3 – 14). Washington, D.C. Falmer press.

Sello, M. (2013). Errors and Misconceptions in Solving Quadratic Equations by Completing Square. *Mathematics Education*. Limpopo South Africa.

Shio, K. J. (2012). Mathematics performance of primary school students in Assam (India); An Analysis using Newman Procedure. *International Journal of Computer Application in Engineering Science vol.2(1) pp. 17-21.*

Siegle, R. S. (2003). Implantation of Cognitive Science *Research for Mathematics Education.*Carenegiamellon University, in Kilpatrick.

Silver, E. A. (1986). Using Conceptual and Procedural Knowledge: A focus on relationship in X. LI (2006). Cognitive Analysis of Students Errors and Misconception in Variables, Equations, and Functions. A Dissertation Submitted to the Office of Graduate Studies of Texas A&M University.

Sorensen, A. (2003). Effective Teaching of High School Mathematics. Singapore press.

Stein, M., Silbert, J. & Carnine, D. (1997). *Designing effective mathematics instruction: a direct instructional approach (3rd ed),* Columbus off: Merril.

Tall, D. O. (2004). *Thinking through three worlds of mathematics. In* :Proceeding 28th Conference of the International Group for the Psychology of Mathematics Education vol.4 pp.281-288. Bergen, Norway; PME

Teoh, S. A. (2010*). The Newman Procedure for Analysing Primary four Pupil Errors on Written Mathematics Tasks*: A *Malaysian* Perspective International Conference on Mathematics Education Research 2010. Vol.8 pp. 264-271.

Tong D.H. & Loc, N.P. (2017). Students errors in solving mathematical word problems and their ability in identifying errors in wrong solutions. *European Journal of Education Studies Vol. 3 (6) pg 226 – 241.*

Trance, N. J. C (2013), process inquiry: Analysis of oral problem-solving skill in mathematics of engineering students. US-China Education Review A, ISSN 2161 – 623 X Vol. 3 No. 2 73 – 82.

VanLehn, K. (1990). *Mind Bugs*. Cambridge, MA: MIT Press.

Vlassis, J. (2002*). The balance Model: hindrance or support for the solving of linear equations with one unknown. Educational studies in mathematics* The Netherlands: Kluwer Academic Publishers volume, 49, pp 341 – 359.