

## **EFFECT OF CONSTRUCTIVIST INSTRUCTIONAL MODEL ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN MATHEMATICS, ENUGU STATE**

By

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### **Abstract**

*This study determined the Effect of Constructivist Instructional Model on Senior Secondary School Students' Achievement in Mathematics, which was guided by two research questions and three research hypotheses. The Constructivist Instructional Model that this study used was Stofflet and Stoddart (1994) constructivist instructional model, which was adopted by Nworgu (1996). The model is a five step instructional constructivism model, which comprised of Prior knowledge, Exploration, Discussion, Dissatisfaction and Application (PEDDA). The design of this study was pretest-posttest non-equivalent control group quasi-experimental design. The population of the study was five thousand, two hundred and seventy-two (5272) Senior Secondary School One (SSS 1) students in the thirty (30) secondary schools. The sample size of the study was four hundred and seven (407) Senior Secondary School One (SSS 1) students in the four (4) sampled coeducational secondary schools in Enugu Education zone. The instrument that was used for pretest and posttest was the Mathematics Achievement Test (MAT), which was developed by the researcher. The instrument underwent face and content validation. The instrument was found to be highly reliable with the reliable coefficient of 0.85 using Kuder-Richardson formula method (K-R 20). Mean ( $\bar{x}$ ) and standard deviations (S) were used in answering the research questions. Analysis of Covariance (ANCOVA) was used in testing the research hypotheses at 0.05 alpha levels. The data gathered were analyzed. From the findings of the analysis, it was discovered that students taught Mathematics using the constructivist-based teaching method (PEDDA) achieved than those with expository method and the difference was statistically significant. The male students taught Mathematics using the constructivist-based teaching method (PEDDA) had higher mean achievement scores than their female counterparts, and the difference was statistically significant. Hence, the study recommended that the use of Constructivist approach (PEDDA) should be included in the Mathematics Curriculum of Teachers' Training tertiary institution so as to popularize its use among the would-be-mathematics teachers.*

### **Introduction**

Education is a systematic process, through which a child or an adult acquires knowledge, experience, skill and sound attitude (Woolgar, 2008). It makes an individual civilized, refined, and cultured for a civilized and socialized society (Nworgu, 1998). Mike (2008) revealed that education remains a focal point for the development of any nation and no nation can toll with its educational system. Hence, the quality and effectiveness of education remains a subject of public discourse (Mulder, 2005). This is because according to Smith (2005), no nation can develop beyond the educational level of its citizenries.

In Nigeria for instance, the National Policy on Education advocates that the citizenries should be self-reliant (Federal Government of Nigeria, 2004), in order for Nigeria to attain a great and dynamic economy (Jumar, 2015). This can be achieved if the learners in Nigeria should be able to see the inter-dependent relationship that exists between academic contents of subjects/courses offered while in school and their real life application for education to be functional. One of the ways of achieving this is through the inculcation of mathematics in the learners (Batiku, 2002). This is because mathematics is the study of

measurement, properties, and relationships of quantities and sets using numbers and symbols. It is the manipulation of the meaningless symbols of a first-order language according to explicit and syntactical rules (Snapper, 2009).

It was as a result of application of mathematics in everyday life of an individual that prompted the Federal Government of Nigeria to make Mathematics a compulsory subject at primary and secondary school levels, though, not all the students are expected to become mathematicians (Oledele, 2004). Yet, mathematics is only subject that has the highest percent of massive poor students' achievement (Oledele, 2004). According to West African Examination (WAEC) Chief Examiners Annual Reports of 2012 to 2015 showed that 38.81% in 2012, 36.57% in 2013, 31.28% in 2014 and 38.68% in 2015 of the total enrolment were able to make up to credit passes in the Senior Secondary School Certificate Examination on Mathematics (WAEC 2012 – 2015, *Vanguards* August 3, 2015). This poor students' achievement is a bad omen for Nigeria judging by the role that mathematics plays in the society.

The observed poor achievement in mathematics at West African Senior Secondary School Certificate Examination (WASSCE) is a good pointer to poor teaching methodology of mathematics (Peter and Peter, 1996; Adegbule, 2000). This explains why some science, technology and mathematics education (STME) researchers among others have in recent times concentrated their research efforts on finding teaching strategies that promote teaching and learning of science so as to increase achievement and enrollments in sciences (Osuafor, 2009).

According to Alio (1997), Onoh (2000), Ogbu (2006) and Adebayo (2010), mathematics teachers have been predominately making use of expository methods, where the teacher dominates the class session, does all the talking and the students do all the listening. The teacher becomes the repertoire of all knowledge. The teacher may ask little standardized questions or none. These methods are simply complete explosive of information, which is presented to students systematically, with no degree of independence (Peter and Peter, 1996; Adegbule, 2000) leading to poor achievement. Emphasis have shifted from expository methods that are teacher-centered and only encouraged rote memorization of facts to strategies that are learner –centered involving hands-on, minds on science activities making the learner active and participative (Nzeni and Osisoma, 2015).

Lebow (1993) revealed that the learner-centered strategies are activity-based and characterized by students sharing some degree of responsibility for making decision in the learning process, and the teacher is often described as a partner and a facilitator in the teaching and learning process and not the possessor of knowledge. According to the Cognitive theorists like the Vygotsky (1962), Piaget (1964), Gagne and Briggs (1974), Stoffert and Stoddart (1994), Nworgu (1996) and Kozulin (2002), the mathematics teachers should make learning an active process, where the learner is being able to monitor and control his learning process. Thus, the students are expected to actually control their attention, acquisition, storage and retrieval of subject matter, mathematics.

Studies indicate that science teaching is a constructive process and that knowledge construction requires active participation on the part of both the learner (Inhelder and Piaget 1958, Piaget 1964) and the teacher (Duckworth, 2006). However to construct knowledge, students must identify and test their existing understandings, interpret the meaning of their ongoing experiences and adjust their knowledge framework accordingly. Also, they must find ways to understand students view points, propose alternative framework, stimulate perplexity among students and develop classroom task that promote effort at knowledge construction (Vosniadou and Brewer, 2015). Proponents of this view are commonly known

as constructivists.

Constructivism is a theory of knowledge with roots in philosophy, psychology and cybernetics. It is defined as that philosophical position which holds that any so-called reality is, in the most immediate and concrete sense, the mental construction of those who believe they have discovered and investigated it (Saunders, 2012). From this perspective, learning is understood to be a self-regulated process of resolving inner conflicts that become apparent through concrete experience, discussion, and reflection.

By this nature, constructivism emphasizes the importance of the teaching context, student prior knowledge, and active interaction between the learner and the content to be learned. There are many Constructivist-Based Instructional Models like the Glynn and Scott model, Gagne and Briggs model, Brunner model, but however, this study shall be based on Stofflet and Stoddart (1994)'s constructivist instructional model, which was adopted by Nworgu (1996). According to Nworgu (1996), the model is a five-step instructional constructivism model, which comprised of **P**rior knowledge, **E**xploration, **D**iscussion, **D**issatisfaction and **A**pplication which is abbreviated as PEDDA. PEDDA provides an outline for instructors who wish to combine the development of reasoning and content mastery. Nworgu (1996) stated that PEDDA is a generalized programmatic approach derived from Piaget theory of intellectual development, especially, the aspect of theory on mental functioning.

According to Stofflet and Stoddart (1994), and Nworgu (1996), the phases of PEDDA correspond to Piaget assimilation, accommodation, organization of knowledge; each phase begins with an activity which allows the students to learn through their own experiences where none originally exists. The new experiences put the students into a state of disequilibrium because questions are raised which the students cannot give answers to (Ezeife, 2010). The ideas and explanations that children generate as they begin to construct ideas, expectations and explorations form a complex framework for thinking about the world and are frequently different from the views of scientists. These differing, alternative conceptions, or alternative frameworks according to Viennot (2009) and Sjoberg and Lie (2011), who stated that student' alternative conceptions may persist despite teaching and students seem to carry the preconceptions along as they progress (consistency). This may not be unrelated to instructional approaches used by Mathematics teachers, which scholars like Alio (1997), Onoh (2000), Ogbu (2006) and Adebayo (2010) have attributed to be the major source of mathematics failure in external examination.

Hence, there is need to explore constructivism approach based on PEDDA model which was developed by Stofflet and Stoddart (1994) and adapted by Nworgu (1996) on secondary school students' achievement in mathematics to determine if it will enhance understanding and acquisition of knowledge of mathematics which can bring about higher and better achievement in mathematics since the previous methods used by the Mathematics teachers have failed to bring the desired higher and better achievement in mathematics. The choice of choosing the PEDDA among other Constructivist-Based Instructional Models is because, this model contains some distinctive features of most Constructivist-Based Instructional Models (CBIM) (Nworgu, 1996), and there is need to evaluate its effect in Senior Secondary school students' mathematics achievement.

Disparity in mathematics achievement based on gender has been a source of worry, while some scholars' findings indicated that females achieve better than their male counterpart in mathematics, others are with contrary opinion. Onoh (2005), Udegbe (2004) and Ahmed (2008) discovered that female students achieved better in mathematics than their

male counterparts, whereas Obodo (1991) and Mike (2008) male students achieved better in mathematics than their female counterparts while Mba (2007) stated that none of the sexes achieved significantly better than the other. Therefore, this study will evaluate the effect of constructivism instructional model (PEDDA) on students' achievement in mathematics based on gender.

### **Purpose of the Study**

The main purpose of this study was to determine the effect of Constructivist instructional model on Senior Secondary School Students' achievement in Mathematics, Enugu State. Specifically, this study determined:

1. the mean achievement scores of Senior Secondary School students taught linear and quadratic equation using the Constructivist instructional model (PEDDA) and those that are taught using expository teaching method (ETM).
2. the mean mathematics achievement scores of male and female Senior Secondary School students in treatment group.

### **Research Questions**

The following research questions below guided this study:-

1. What are the mean achievement scores of Senior Secondary School students taught Mathematics using the constructivist instructional model (PEDDA) and those that are taught Mathematics using expository teaching method (ETM)?
2. What are the mean achievements scores of male and female Senior Secondary School students in treatment group?

### **Research Hypotheses**

The following null hypotheses which were tested at 0.05 levels of significances, guided this study.

- Ho1: There is no significant difference in the mean achievement score of students taught mathematics using PEDDA and those taught using ETM.
- Ho2: There is no significant difference in the mean achievement score of male and female students in treatment group.
- Ho3: There is no significant interaction effect of method and gender on the achievement score of students in mathematics.

### **Research Methods**

The design of this study was pretest-posttest non-equivalent control group quasi-experimental design. This study was conducted in secondary schools in Enugu Education zone of Enugu State. The population of the study was five thousand, two hundred and seventy-two (5272) Senior Secondary School One (SSS 1) students in the thirty (30) secondary schools. The sample size of the study was four hundred and seven (407) Senior Secondary School One (SSS 1) students in the four (4) sampled coeducational secondary schools in Enugu Education zone. The instrument that was used for pretest and posttest was the Mathematics Achievement Test (MAT), which was developed by the researcher. The instrument underwent face and content validation. The instrument was found to be highly reliable with the reliable coefficient of 0.85 using Kuder-Richardson formula method (K-R 20). The study used the regular mathematics teachers as this study's research assistants. The experiment lasted for four weeks. Mean and standard deviation (s) were used in answering

the research questions while Analysis of Covariance (ANCOVA) was used in testing the research hypotheses at 0.05 alpha levels.

**Data Analysis**

**Research Question 1:**

What are the mean achievement scores of Senior Secondary School students taught Mathematics using the Constructivist instructional model (PEDDA) and those that are taught Mathematics using expository teaching method (ETM)?

**Table 1: Mean Achievement Scores of Students that are taught Mathematics in Treatment and Control Groups**

Groups	Number	Pre-test		Post-test	
		Mean ( $\bar{x}$ )	Standard Deviation (s)	Mean ( $\bar{x}$ )	Standard Deviation (s)
Treatment Group	199	23.33	5.98	27.94	4.41
Control Group	208	21.13	3.57	22.90	4.62
<b>Total</b>	<b>407</b>				

Table 1 above displayed the result of Mean Achievement Scores of Students that are taught Mathematics in Treatment and Control Groups. From the results of the analysis, the pre-test mean achievement score and standard deviation for the treatment group were 23.33 and 5.98 respectively, while the post-test mean achievement score and standard deviation were 27.94 and 4.41 respectively. On the other hand, for the control group, pre-test mean achievement score and standard deviation were 21.13 and 3.57 respectively, while post-test mean achievement score and standard deviation were 22.90 and 4.62 respectively.

From this analysis, it showed that learning took place. This is because the two groups achieved higher mean score in their posttest than their pretest. However, the posttest mean achievement score of the treatment group was higher than the control group. The treatment group also had a lower standard deviation than the control group. This implied that there were fewer extreme scores in the treatment group than the control group because the control group had higher standard deviation score than the Treatment group in posttest.

**Research Question 2:**

What are the mean achievements scores of male and female Senior Secondary School students in treatment group?

**Table 2: Mean Achievement Scores of Male and Female Students in Treatment Group**

Groups	Number	Pre-test		Post-test	
		Mean ( $\bar{x}$ )	Standard Deviation (s)	Mean ( $\bar{x}$ )	Standard Deviation (s)
Male	101	23.17	5.08	29.43	0.98
Female	98	23.49	6.81	26.41	5.83
<b>Total</b>	<b>199</b>				

Table 2 showed the mean achievement scores and standard deviations of male and female students in treatment group in both Pretest and Posttest. From the results of the analysis, the pre-test mean achievement score and standard deviation for the male students were 23.17 and 5.08 respectively, while the post-test mean achievement score and standard deviation were 29.43 and 0.98 respectively. On the other hand, for the female students, pre-test mean achievement score and standard deviation were 23.49 and 6.81 respectively, while post-test mean achievement score and standard deviation were 26.81 and 5.83 respectively.

The male students had a mean difference of 6.26 and their scores were not scattered. In other words, their scores were clustered towards 26.81 unlike their female counterparts that had scattered scores and a mean difference of 2.92.

**Testing of the Research Hypotheses**

Three null hypotheses which were tested at 0.05 levels of significance guided the study. The hypotheses were tested using the Mean, Standard Deviation and ANCOVA. The results were shown in tables 4 to 6 below:

**HO<sub>1</sub>:** There is no significant difference in the mean achievement score of students taught mathematics using PEDDA and those taught using ETM.

**Table 3: Analysis of Covariance (ANCOVA) on the Mean Achievement Scores of Students in Treatment and Control Groups**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	2579.099 <sup>a</sup>	1	2579.099	126.498	.000	Ho Rejected
Intercept	13162.376	1	13162.376	645.578	.000	
GROUP	2579.099	1	2579.099	126.498	.000	
Error	8257.353	405	20.389			
Total	272716	407				
Corrected Total	10836.452	406				

Table 3 showed the Analysis of Covariance (ANCOVA) on the mean achievement scores of students in treatment and control groups. In table 3, groups (treatment and control) as main effect, gave an f-value of 126.498 and was significant at 0.000. Since .000 was less than 0.05, this meant that at 0.05 significant level, the f-value was significant. Hence, hypothesis 1 was rejected as stated. The study therefore, concluded that there was significant difference between the mean achievement score of students taught mathematics using PEDDA and those taught using ETM. This gives an indication that students taught mathematics using PEDDA achieved better than the students taught using ETM.

**HO<sub>2</sub>:** There is no significant difference in the mean achievement score of male and female students in treatment group.

**Table 4: Analysis of Covariance (ANCOVA) on the Mean Achievement Scores of Male and Female Students in Treatment Group**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	452.910 <sup>a</sup>	1	452.910	26.286	.000	Ho Rejected
Intercept	21132.514	1	21132.514	1226.475	.000	
GENDER	452.910	1	452.910	26.286	.000	
Error	3394.367	197	17.230			
Total	159192	199				
Corrected Total	3847.276	198				

Total						
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Table 4 presented the Analysis of Covariance (ANCOVA) on the mean achievement scores of male and female students in treatment group. In table 4, gender (male and female) as main effect, gave an f-value of 26.286 was not significant at 0.000. Since 0.00 was less than 0.05, this meant that at 0.05 level, the f-value was significant. Therefore, hypothesis 2 was rejected as stated. Hence, the study concluded that there was significant difference between the mean achievement scores of male and female students in treatment group. This gives an indication that male students achieved better than the female students in the treatment group.

**HO<sub>3</sub>:** There is no significant interaction effect of method and gender on the achievement score of students in mathematics.

**Table 5:** Analysis of Covariance (ANCOVA) on the interaction between method and gender on students' achievement in Mathematics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	3449.592 <sup>a</sup>	2	1724.796	94.332	.000	Ho Rejected
Intercept	13150.938	1	13150.938	719.247	.000	
GENDER * GROUP	3449.592	2	1724.796	94.332	.000	
Error	7386.860	404	18.284			
Total	272716	407				
Corrected Total	10836.452	406				

Table 5 above shows the interaction effect between method and gender on students' achievement in Mathematics. The results indicated that the main interaction effect gave an f-value of 94.332 and this was significant at 0.000. Since 0.000 was less than 0.05, this meant that at 0.05 level, the f-value of 94.332 was significant. This implied that the method influenced significantly the students' achievement in Mathematics. The study therefore, concluded that there was significant interaction between gender and methods on students' achievement in Mathematics.

### Summary of Findings

Results of the analysis revealed the following:

1. Learning took place. This is because the two groups achieved higher mean score in their posttest than their pretest. However, the treatment group had higher mean post achievement score and lower post standard deviation than the control group.
2. There was significant difference between the mean achievement score of students taught mathematics using PEDDA and those taught using ETM. This gives an indication that students taught mathematics using PEDDA achieved better than the students taught using ETM.
3. There was significant interaction between gender and methods on students' achievement in Mathematics.

### Discussion of the Findings

This study investigated the effect of Constructivist instructional model on Senior Secondary School Students' achievement in Mathematics. The study was guided by two (2) research questions and three (3) research hypotheses. The research questions and research hypotheses were analyzed in tables 1 to 5 respectively. Table 1 examined Mean Achievement Scores of Students that are taught Mathematics in Treatment and Control Groups in both Pretest and Posttest. From the table, it was discovered that Constructivist Instructional Model Approach (PEDDA) produced differential effects on students' achievement in Mathematics. This finding agreed with the discovery in table 3.

Table 3 examined the Analysis of Covariance (ANCOVA) on the mean achievement scores of students in treatment and control groups. In the table 3, it was established that there was significant difference between the mean achievement score of students taught mathematics using PEDDA and those taught using ETM and since that the experimental group achieved better, it means that the Constructivist Instructional Model Approach (PEDDA) makes students to have a better achievement. This discovery is in line with Boaler (2008)'s assertion that students that are exposed to constructivism perform well on the same tests than the other students who were taught by more traditional mathematics teachers in the same school and the students could cover three times the material. This is because it uses scaffolding provided by teacher or group, for individual problem solving (Wilson & Cole, 2011).

In terms of students' achievement in mathematics with respect to gender, table 2 examined the mean achievement scores and standard deviations of male and female students in treatment group in both Pretest and Posttest. It was discovered that male students had higher mean and standard deviation scores compared to their female counterparts. This discovery tailed with the discovery of table 4, which revealed that there was significant difference between the mean achievement scores of male and female students in treatment group and table 5 that revealed that there was significant interaction between gender and methods on students' achievement in Mathematics. The implication of this discovery is that male students achieved better than the female students. This discovery was in line with Obodo (1991)'s and Mike (2008)'s assertion that the male students achieved and retained better in mathematics than their female counterparts. According to Asiegbu (2000), women are not involved more in handling science (especially mathematics) applications starting from their homes, it has resulted in making the girls' achievement in mathematics to be less than their boys' and has made female enrolment in science particularly physical science and mathematics in the secondary schools in recent times to be at decline rate (Heam, 2002).

## **Conclusion**

This study investigated the effect of Constructivist instructional model on Senior Secondary School Students' achievement in Mathematics, Enugu State. From the findings of the study, it was deduced that the use of Mathematics Constructivist approach (PEDDA) was effective in teaching the Mathematics in schools. This made the treatment group taught with the Mathematics Constructivist approach (PEDDA) achieved significantly higher mean scores in Mathematics. This implied that the Mathematics Constructivist approach (PEDDA) made the students to understand question faster, respond sharply and achieved better than the students taught the expository method. It was also deduced from the findings of the study that male gender achieved better than their female counterpart than their female counterpart in Mathematics in Experimental lessons.



### Recommendations

Based on the above implications and findings of the study, the following recommendations are made:

1. As the use of Constructivist approach (PEDDA) has been found effective in promoting achievement and retention in Senior Secondary School Mathematics and since this teaching method is relatively new in Nigeria, it should be included in the Mathematics Curriculum of Teachers' Training tertiary institution, so as to popularize its use among the would-be-mathematics teachers and hence bring about more effective learning of Mathematics in our secondary schools.
2. The serving teachers of mathematics should adopt the use of Constructivist approach (PEDDA) in Mathematics lessons.
3. Federal/State Governments, Post- Primary Schools Management Boards and the Nigerian Educational Research Development Council (NERDC) should design and revise the Mathematics curriculum for secondary schools to incorporate and emphasize the use of Constructivist approach (PEDDA) in the teaching of senior secondary schools Mathematics.

### References

- Adebayo E. (2010). *The History and Methodology of Mathematics*. Ibadan: Labode Printing Press.
- Adegbule, B.D. (2000). Relative Effectiveness of Models and Computer Assisted Instruction Software in Teaching and Learning of Mathematics in Junior Secondary Schools. *An Unpublished MED Thesis*. Usman Dan Fodio University, Sokoto State.
- Ahmed U. U. (2008). Effect of Computer Simulation in Junior Secondary School Students' Achievement, Interest and Retention. *Journal of Research in Education* 1(1): 64 -72.
- Alio B. C. (1997). Effect of Polya's Problem Solving Technique on Secondary School Students' Achievement in Mathematics. *ABACUS: Journal of Mathematics Association of Nigeria*.
- Asiegbu, F. V. (2000). Towards Improving Female Enrolment in Physical Sciences in Secondary Schools. *A paper presented at the First National Conference on Effective Science and Computer Education Programme* organized by Science and Computer Education Department of Enugu State University of Science and Technology (ESUT), Enugu.
- Batiku, A.A. (2002) Evaluation of Nigeria Mathematics Curriculum. *An unpublished Assignment*
- Boaler, J. (2008). Open and closed mathematics: Student experiences and understandings. *Journal for Research in Mathematics Education*, 29 (1), 41-62.
- Federal Government of Nigeria (2004). *National Policy on Education*. Abuja: NERDC
- Gagne R.M. and Briggs, L. (1974). *Principle of Instructional design*. New York: Halt Rinehart and Winston Ltd.
- Heam J. (2002). Notes on Patriarchy Professionalization and Semi-Professionalization. *Sociology* 16(1), 184 – 202.
- Inhelder B. and Piaget, J. (1958). *The Psychology of the Child*. Translated by H. Weaver. New York: Basic Books.
- Jumar Maranon Valdez (2015). Constructivist method: Effects on Achievement and Retention in Analytic Geometry. *International Journal of Engineering and Technical Research (IJETR)* ISSN: 2321-0869, Volume-3, Issue-1, 300 – 305
- Kozulin, A. (2002). *Sociocultural theory and the mediated learning experience*. *School Psychology International*. Cambridge, London, UK: Sage Publications
- Mike C.T. (2008). Effects of Coordinate Geometry Games on Junior Secondary School Students in Coordinate Geometry. *Journal of Association of Educational Professionals*, 16 (2); 1 – 13.
- Mulder, W. (2005). Higher Education should make use of meal problem. *Management* 3 (2), 6 – 11.

- Nworgu, B.G. (1996). Teaching for a conceptual understanding of physics. A conceptual-change instructional model. *A lead paper presented on the 37th annual conference of STAN held at Uyo.*
- Nworgu, B.G. (1998). Constructivism: A new trend in science teaching. UNICEF/Imo State Primary Education Board TOT Workshop on the Teaching of Four Core Primary School Subjects.
- Nworgu, B.G. (2006). *Educational Research Basic Issues and Methodology*. Nsukka: University Trust Publishers.
- Nzeni D. and Osisioma B. (2015). Applying constructivism: A test for the learner as scientist. *Educational Technology Research and Development*, 47(3), 15 – 31
- Obodo, G. C. (1991). Implementation of the Junior Secondary School Mathematics Curriculum in Nigeria: Problems and Remediation, *Journal of Studies in Education* (2)1, pg. 18 .
- Ogbu, S. (2006). Effect of Simulation-Games on Students' Achievement and Interest in Mathematics. *An Unpublished M. Sc. (Ed.) Dissertation submitted at the Enugu State University of Science and Technology (ESUT), Enugu.*
- Oledele, O. (2004) *Students Life in a Class Society*. Ile Ife: Olowo Publishers
- Onoh D. O. (2000). Effect of two Solution Strategies in Solving Mathematical Problem on JSS 1 Students' Achievement, Interest and Retention in Mathematics. *An Unpublished M. Sc. (Ed.) Dissertation submitted at the Enugu State University of Science and Technology (ESUT), Enugu.*
- Osuafor (2009). [STME education for 14-19 year olds](#) *Science and Technology Journal* 4(2): 1 -15
- Piaget, J. (1964). Development and learning. *Journal of Research in Science Teaching*, 2, 176-186.
- Saunders, W.L. (2012). The Constructivist Perspective: Implications and Teaching Strategies for Science. *School Science Mathematics*, 92 (3), 136-141.
- Sjoberg S. and Lie S.(2011). *Ideas about force and moment among Newselagin pupils and students*. Osier: University of Osier Press
- Smith W. G. (2005). *The Need for Whole System and not piecemeal, reform in Mathematics Education*. Slough: Green Landers Press.
- Snapper E. (2009). The Three Crises in Mathematics: Logicism, Intuitionism, Formalism. *Mathematics Magazine* 64(4): 14 – 18.
- Stofflet, R.T. and Stoddart, T. (1994). The Ability to understand and use conceptual change pedagogy as a function of prior content learning experiences. *Journal of Research in Science Teaching* 3(1), 31 – 51.
- Udegbe, I. (2005). The Effect of the use of Templates and Rolligraph as instructional material on students' achievement and interest in Mathematics. *An Unpublished Ph.D thesis submitted at Enugu State University of Science and Technology, (ESUT), Enugu.*
- Vanguards (August 3, 2015). A daily newspaper. Lagos: Vanguards Press.
- Viennot L. (2009). Spontaneous reasoning in elementary dynamics. *European Journal of Science Education* 1, 205 – 224.
- Vosniadou J. and Brewer P.N. (2015). Spontaneous Reasoning in elementary dynamics. *European Journal of Science Education* 36: 205 – 224.
- Vygotsky, L. (1962). *Thought and language (E. Hanf-mann & G. Vakar, Trans.)*. Cambridge, MA: MIT Press.
- West African Examination Council (WAEC) (2012, 2013, 2014, 2015) May/June Senior Secondary School Certificate Examination. *Chief Examiner's Report* , Lagos: WAEC
- Wilson, B. & Cole, P. (2011). *A Review of Cognitive Teaching* in Burz, H.L., & Marshall, K. (2016). *Performance-Based Curriculum for Mathematics*. Thousand Oaks, Ca: Corwin Press, Inc.
- Woolgar S. (2008). *Science the Very Idea*. London: Tavistock Publications