# Effect of 5Es Constructivist Instructional Approach on Male and Female Students' Achievement and Retention in Chemistry in Benue State, Nigeria

Aondohemba John GARBA

*Department of Science Education, Federal University of Agriculture Makurdi, Nigeria*

***Abstract*: - The study investigated the effect of 5Es constructivist instructional approach on senior secondary students' achievement and retention in chemistry in Benue State, Nigeria. Two research questions and two hypotheses guided the study. The quasi experimental design was used for the study. A sample of 132 senior secondary two students from six secondary schools was selected using purposive and random sampling techniques. Two instruments, Chemistry Achievement Test (CAT) and Chemistry Retention Test (CRT) were developed by the researcher. The instruments were validated by five experts. Upon successful validation, the instruments were trial-tested in a pilot study. Kuder-Richardson (K-$R_{21}$) formula was used to find the reliability coefficient of the CAT which was found to be 0.71. Data were collected at various intervals using the CAT and CRT. The data collected were analyzed using mean and standard deviations to answer the research questions while analysis of covariance (ANCOVA) was used in testing the hypotheses at 0.05 level of significance. The analysis of the data revealed that there was no significant difference in the mean achievement scores of male and female students taught Chemistry using constructivist instructional strategy. In terms of retention there is a significant difference in the mean retention scores of male and female students with female students having the highest mean retention scores. It is concluded in this study that the use of constructivist instructional strategy enhance students' achievement and retention in Chemistry. It was recommended that Chemistry teachers should use constructivist instructional strategy which provides students opportunity to interact with materials, teachers and peers.**

***Keywords:*** **Chemistry Education, 5Es, Gender and Achievement, Constructivist Instructional Approach**

## I. INTRODUCTION

The important role of science in the economic growth of any nation in contemporary times cannot be overemphasized. In Nigeria, the importance of chemistry in the development of the nation cannot be underrated especially as her national income rests mainly on petroleum and petrochemical industries (Ameh & Dantani, 2012). Chemistry deals with the study of the composition, properties and use of matter (Okebukola, 2006). Chemistry is an important science subject that occupies a prominent place in science curriculum especially at the senior secondary school level. It serves as a prerequisite to the study of medicine, pharmacy, agriculture, engineering and textile and clothing (Uwague & Ojebah, 2008). Uwague and Ojebah (2008) further observe that chemistry is pre-occupied with the molecular transformation and manifestation of matter. This implies that chemistry is involved in industrial set-up (fertilizer, petroleum and cement), the execution of other professions (engineering, agriculture, criminology and medicine) and the improvement of quality of life of the citizenry. A credit in chemistry is also a necessary prerequisite for admission into all science courses such as medicine, engineering and agriculture at the university level (Uwague & Ojebah, 2008).

Despite the importance of chemistry, students' achievement in chemistry has been very poor. Madu & Ezeamagu (2013) defined achievement as the quality and quantity of a student's work feat. Akem (2007) sees achievement as success or result gained by students after being exposed to a learning program. Achievement is a yardstick which determines the success or failure of teaching-learning process. Research report such as Okebukola (2006) found that students achieve poorly in chemistry at the senior secondary school certificate examination. Available statistics from the West African Examination Council in the May/June West African Senior Secondary School Certificate Examination for a period of 5 years (2007-2012) also brought to lime light the fluctuating yet persistent under achievement of students in chemistry (as shown in Appendix A pp 79).

A critical look at the results revealed that the proportion of students who achieved a credit level pass (A1-C6) is considerably lower (43.69-50.70%), compared to the proportion of students who achieved ordinary pass and failing grades (P7-F9) which is larger (49.30-56.31%). It was also revealed that throughout the period 2007-2014 only in 2010 that chemistry students were able to record up to 50% credit pass. All these show that the achievement of chemistry students at the secondary school level has been poor and deplorable over the years. This does not augur well for the country given the position of chemistry in scientific, technological and economic development of Nigeria as she looks forward to be one of the 20$^{th}$ most scientifically, technologically and economically developed nations of the world by the year 2020 (Vision 20:2020).

The teaching strategy used by the teacher has great influence on students' achievement (Ogbu, 2011). Poor teaching method was observed by Agogo and Naakaa (2014)

as one of the major causes of students' dismal achievement in science. Though, the authors submit that no single method is best for the teaching of science, they unanimously agree that methods that would involve students' active participation such as field work, laboratory work, group work, concept mapping and inquiry methods would ensure higher achievement.

Samba and Eriba (2012) put the blame of poor achievement in chemistry on the classroom teacher's professional training which may have affected their methods of teaching. The teacher's ineffective teaching method employed is a major factor in students' poor achievement, especially in science (Madu and Ezeamagu (2013). In its true form, the conventional method is characterized by a one-way flow of information from the teacher, who is active throughout the lesson to the students who are passive listeners. For this reason, the conventional method is said to be didactic in nature because most of the talking is carried out by the teacher while the students remain as passive listeners, taking down note (Albert, 2000). Ezenwa (2003) observed that most teachers use conventional teaching method instead of more innovative problem solving based/inquiry based method. The situation is worsened by acute shortage of competent science teachers to handle science equipment.

To bring about improvement in science teaching, researches have been conducted with the intention of finding out the best approach to teaching science in Nigeria. For instance, Okebukola (2006) working on the new "Benchmark for Minimum Academic Standards (BMAS) for secondary school advocated for a re-examination of instructional approaches to teaching of science subjects in our secondary schools. This kind of re-examination of instructional strategies is pertinent today especially in the teaching of science subjects and chemistry in particular given the importance of chemistry to industrial development of Nigeria.

Nwagbo and Obiekwe (2006) attributed failure in Chemistry to a number of factors among which include lack of qualified chemistry teachers and equipment, inappropriate medium of instruction, poor class room management, admission of unqualified students and students' perception of difficulty in some Chemistry concepts. Similarly Adagba (2013) have attributed the problem to non-availability of necessary facilities for the teaching of Chemistry among other things in addition to students' socio-economic background and intelligence. The teachers on their part blame the management of the system for not providing adequate equipment or materials as well as poor conditions of service (Babayi, 2006).

The low achievement in chemistry is also blamed on the difficulty of the topics in senior secondary chemistry curriculum. Samba and Eriba (2012) identified difficult topics in senior secondary chemistry to include electrolysis, atomic structure, periodicity of elements, nuclear chemistry, mole and molarity, hybridization, chemical nomenclature, entropy and enthalpy and balancing of chemical equation(s). Students found electrolysis and atomic structure difficult as ranked by their teachers, followed by hybridization and chemical nomenclature (Samba and Eriba, 2012). It is among these difficult topics that the efficacy of the constructivist instructional approach was investigated.

Tsoho (2010) identifies teaching strategy as a key factor in retention of the studied material. Woolfork (2008) described retention as the ability to retain or remember facts and figures in memory. Similarly, Igboko and Ibeneme (2006) defined retention as the ability of an individual to hold factual knowledge, skills, processes, images and figures in memory and at the same time retrieved for use when the need arises. Thus Ortese , Yawe and Akume (2005) affirmed that learning cannot take place in the absence of retention. In confirming this Chianson, Kurumeh, and Obida, (2010) stated that researchers identified that how well students retain taught mathematics and scientific concepts can be traced back to the teaching approach used. The researchers further submitted that teaching strategies that involve the active participation of the learner encourage retention while strategies that the learner receives information passively leads to little or no retention.

To Ausubel (1968) learners who possess well organized cognitive structures tend to retain information effectively. Conversely, learners who have poorly organized cognitive systems tend to forget information rapidly. Thus, Ausubel (1968: 128), stated that "it is largely by strengthening relevant aspects of cognitive structure that new learning and retention can be facilitated". Ortese, Akume and Yawe (2005) affirmed that retention is enhanced when the teacher uses approaches that appeal to multiple senses of the learner and also actively involve the learner in the teaching learning process. Hence chemistry concepts need to be presented to the learners in a way or method that is learner centred and appealed to learners multiple senses which can trigger quick recalling of the concept being taught or learnt. However, it is not yet known whether using a teaching strategy such as the 5Es (engaging, exploring, explanation, elaboration and evaluation) can enhance retention of learnt concepts among chemistry students in Makurdi Local Government Area.

The desire to improve students' achievement and retention through more effective instructional strategies and the increasing awareness in recent years of learner centeredness has focused attention to understanding how learners learn and how to help them learn. This led to the development of meta-cognitive strategies. Meta-cognitive strategies involve the empowerment of the learner to take charge of his/her own learning in a meaningful way. The fact is that all knowledge is constructed from a base of prior knowledge of the learner as expressed in the constructivist theory of learning (Vygotsky, 1924)

Constructivist learning holds that people construct their own understanding and knowledge of the world, by experiencing things and reflecting on those experiences

(Vygotsky, 1924). When a learner encounter something new, he has to reconcile it with his previous ideas and experiences, may be by changing what he believes, or discarding the new information as irrelevant. In any case, the leaner is an active creator of his own knowledge. To do this, he must ask questions, explore, and assess what he knows. This theoretical framework holds that learning always builds upon knowledge that a student already has. This prior knowledge is what Bruner (1966) called a "schema" while Ausubel (1962) called it "subsumer". Because all learning is filtered through pre-existing schemata, constructivists suggest that learning is more effective when a student is actively engaged in the learning process rather than attempting to receive knowledge passively (Hansen, 2001).

A wide variety of constructivist learning models have been developed. These include: The Information Construction (ICON) model, the pupil-centered inquiry model (Free Inquiry), the Learning Cycle model, the 5 E's model, the social interaction models and discovery model by Bruner among others (Sara, 2003; Hassard, 2006). Most of these methods rely on some forms of guided discovery where the teacher avoids most direct instruction and attempts to lead the student through questions and activities to discover, discuss, appreciate, and verbalize the new knowledge (Hassard, 2006).

One of the constructivist strategies is the 5Es ( Engage, Explore, Explain, Elaborate, and Evaluate). The 5Es instructional strategy was developed by the Biological Science Curriculum Study (BSCS). The 5Es represent five stages of a sequence for teaching and learning: Engage, Explore, Explain, Extend (or Elaborate), and Evaluate. The purpose for the engage stage is to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding. The explore stage tries to get students involved in the topic; providing them with a chance to build their own understanding. The explain stage provides students with an opportunity to communicate what they have learned so far and figure out what it means. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways.

The last stage is the evaluation stage which is for both students and teachers to determine how much learning and understanding has taken place. The postulation that constructivist instructional strategies, especially the 5Es instructional strategy improve students' achievement and retention is at best ideal as expressed in literature but the classroom situation in its application is yet to be determined especially in chemistry. It therefore becomes necessary to direct research towards such innovative constructivist teaching strategy.

From the forgoing, it could be seen that the 5Es instructional strategy provides equal learning opportunities for students of all gender at various stages. Thus making it suitable for a study that involves gender as a moderation variable. The influence of student's gender on achievement has continued to be an issue of concern in science education research. Sinnes (2005) states that what both the feminist empiricist and the liberal feminist critics seem to agree on is that females in principle will produce exactly the same scientific knowledge as males provided that sufficient rigor is undertaken in scientific enquiry.

Longe and Adedeji (2003) particularly affirmed that science and technology is a male-dominated subject and that, females tend to shy away from scientific and technological fields. Boys therefore appear to have a natural positive attitude to technical and science subjects while girls show negative attitude. This negative attitude according to Babajide (2010) is due to the acceptance of the myth that boys are better in science subjects than girls. For instance between 2007 and 2011 boys recorded higher percentage of credit passes than girls in physics and chemistry in WAEC (WAEC Chief Examiner's report, 2012).

Many researchers have provided reports that there are no distinguishing differences in the cognitive, affective and psychomotor skill achievement of pupils in respect of gender (Bilesanmi-Awoderu, 2012; Oludipe, 2012). However, Aguele and Agwuga (2007) in their studies found that male students achieved better than female students in the cognitive, affective and psychomotor skills. The gap in achievement in science between genders widens in favour of boys in co-educational schools but not in single sex schools (Dipilla, 2001). This wide gender gap in students achievement in science in co-education schools has been attributed to unconducive classroom environment for girls due to intense sex role stereotyping and apparent boys domination of science learning activities (Mari, 2002).

Oludipe (2012) concluded that some cognitive gender differences were well established; girls have greater verbal ability (communication) than boys and boys have better visual-spatial ability (observation) than girls. Similarly Mari (2002) demonstrated the superiority of girls over boys in use of science process skills. Ezeh (2004) suggested that gender stereotypes in classroom can be broken by adopting teaching strategies that give equal opportunities to both boys and girls. While Bowlby in Ogbeba (2009) affirms that female students perform better than their male counterparts with the use of inquiry method.

It is note-worthy that these various researchers have come out with different findings. Therefore there is need to give boys and girls exactly the same opportunity and challenges using the 5Es instructional strategy in this study to enable the researcher ascertain the extent of match or mismatch in their achievement and retention.

*Statement of Problem*

Over the years various reports have revealed the poor achievement of students in science subjects in general and chemistry in particular. Many researchers have agreed that the

poor achievement is caused by wrong and poor pedagogies used by chemistry teachers, inadequate infrastructures such as libraries and laboratories. The persistent poor achievement in science subjects especially chemistry among students makes it imperative to search for better teaching approaches for effective teaching and learning of chemistry concepts.

This poor achievement in chemistry should be taken as a wake-up call to re-examine the methodologies in use, to prevent it from constituting a clog to the wheel of educational progress of many Nigerian students offering chemistry. This is because a credit in chemistry is required for admission into medical, engineering and other science technological related courses at the university level. It therefore follows that if the poor achievement in chemistry at the secondary school continues, there may be no candidate for admission into these courses at the tertiary level. Therefore, there is need to search for innovative teaching approaches that could improve students' achievement and retention in chemistry. This is precisely the concern of this study.

Furthermore, influence of gender on achievement in science continues to be a debate among science education researchers. While some studies reported that there are no distinguishing differences in the cognitive, affective and psychomotor skill achievement of students in respect of gender. Other studies found that male students achieved better than female students in the cognitive, affective and psychomotor skill achievements. These disparities among research studies need more empirical evidence for better understanding of influence of gender on students' achievement in science especially in chemistry.

It thus becomes imperative that new approaches for revolutionizing the teaching and learning of science in general and chemistry in particular must be researched into, more so that available teaching methods do not seem to address this problem of decline in students' achievement and retention. Thus, the problem of this study put in question form is that will the use of constructivist instructional strategy help to improve students' achievement and retention in chemistry?

*Purpose of the study*

The purpose of this study is to investigate the efficacy of the 5Es instructional approach on students' achievement and retention in chemistry. Specifically the study sought to:

1. Find out whether the use of 5Es constructivist instructional approach bridged the gap in SS II male and female students' achievement in Chemistry.
2. Find out whether the use of 5Es constructivist instructional approach bridged the gap in SS II male and female students' retention in Chemistry.

*Research Questions*

The study was guided by the following research questions.

1. What are the mean achievement scores of male and female SS2 students taught chemistry using the 5Es constructivist instructional approach?
2. What are the mean retention scores of male and female SS2 students taught chemistry using the 5Es constructivist instructional approach?

*Hypotheses*

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

1. There is no significant difference between the mean achievement scores of male and female SS2 students taught chemistry using 5Es instructional approach.
2. There is no significant difference between the mean retention scores of male and female SS2 students taught chemistry using the 5Es instructional approach.

## II. METHODOLOGY

The study adopted the non-equivalent control group, pre-test, post-test quasi experimental design. A sample of 132 senior secondary two students from six secondary schools was selected using purposive and random sampling techniques. Two instruments, Chemistry Achievement Test (CAT) and Chemistry Retention Test (CRT) were developed by the researcher. The instruments were validated by five experts. Upon successful validation, the instruments were trial-tested in a pilot study. Kuder-Richardson (K-$R_{21}$) formula was used to find the reliability coefficient of the CAT which was found to be 0.71. Both male and female students were taught using the 5Es constructivist instructional approach for a period of six weeks. Data were collected at various intervals using the CAT and CRT. The data collected were analyzed using mean and standard deviations to answer the research questions while analysis of covariance (ANCOVA) was used in testing the hypotheses at 0. 05 level of significance.

## III. RESULTS

The results of this study are presented according to the research questions and hypotheses.

*Research Question one*

What are the mean achievement scores of male and female students taught chemistry using the 5Es constructivist instructional approach? Answer to this research question is presented in Table 1.

**Table 1:** Means and Standard Deviations of Male and Female SS II Students' Achievement Scores when Taught with 5Es Approach

| Gender | N | Pretest mean | SD | Posttest mean | SD | Mean Gain |
|---|---|---|---|---|---|---|
| Male | 74 | 34.42 | 6.27 | 63.67 | 11.9 | 29.25 |
| Female | 58 | 34.13 | 6.10 | 62.90 | 12.02 | 28.77 |
| Mean Different | | 0.29 | | 0.77 | | |
| Total | 132 | | | | | |

Table 1 shows that the mean achievement scores of male and female students in the pre-test were 34.42 and 34.13 respectively. Their mean difference is 0.29. The standard deviation was 6.27 for male and 6.10 for female in the pre-test.Thetable also shows that in the post test, the mean achievement score of male students was 63.67 and standard deviation of 11.9 while female students have a mean achievement score of 62.9 and standard deviation of 12.07. Their mean difference is 0.77. The corresponding hypothesis is presented below.

*Hypothesis One*

There is no significant difference between the mean achievement scores of male and female SS 2 students taught chemistry using 5Es instructional approach. The test result of this hypothesis is presented in Table 2.

Table 2**: ANCOVA Result of SS II Male and Female Students Achievement taught Chemistry with 5Es.**

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Corrected Model | 7044.83[a] | 2 | 7044.83 | 48.50 | .000 | Significance |
| Intercept | 345384.10 | 1 | 345384.1 | 2377.75 | .000 | Significance |
| Pretest | 106.599 | 1 | 106.599 | 28.387 | .000 | |
| Gender | 7044.83 | 1 | 7044.83 | 48.50 | .26 | Not Significance |
| Error | 18883.41 | 129 | 145.26 | | | |
| Total | 388704.00 | 132 | | | | |

Table 2 shows the calculated F-value for the achievement scores of male and female SS 2 students taught chemistry using 5Es constructivist instructional approach is 48.50 with a significant value of 0.26 which is greater than 0,05 being the value for the study. The null hypothesis is therefore not rejected.

*Research Question Two*

What are the mean retention scores of male and female SS2 students taught chemistry using the 5Es constructivist instructional approach? Answer to this research question is presented in Table 3.

**Table 3.** Mean and Standard Deviation of SS II Male and Female Students Retention taught with 5Es approach **.**

| Gender | N | Post-test mean | SD | Retention test mean | SD |
|---|---|---|---|---|---|
| Male | 74 | 63.67 | 11.9 | 66.90 | 12.19 |
| Female | 58 | 62.90 | 12.02 | 68.30 | 12.62 |
| Mean difference | | 0.77 | | 1.40 | |
| Total | 132 | | | | |

Table 3 reveals that male students have a mean retention scores of 63.67 and standard deviation of 11.90 while female have a mean of 62.90 and standard deviation of 12.02 in the post-test. Their mean difference is 0.277. In the post-post test male students have a mean retention score of 66.90 and standard deviation of 12.19 while the female students have a mean retention scores of 68.30 and standard deviation of 12.62. Their mean difference is 1.40.

*Hypothesis Two*

There is no significant difference between the mean retention scores of male and female students taught chemistry using the 5Es instructional approach. The test result of this hypothesis is presented in Table 4.

Table 4: ANCOVA Result of SS II Male and Female students Retention taught with 5Es.

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Corrected Model | 9726.323[a] | 2 | 9726.32 | 74.46 | .000 | Significance |
| Intercept | 343699.66 | 1 | 343699.66 | 2631.33 | .000 | Significance |
| Pretest | 106.599 | 1 | 106.599 | 28.387 | .000 | significance |
| Gender | 9726.32 | 1 | 9726.32 | 74.46 | .000 | Significance |
| Error | 16980.40 | 129 | 130.62 | | | |
| Total | 389902.00 | 132 | | | | |

Table 4 reveals that F-value for the Male and Female students retention scores in Chemistry taught with 5Es is 74.68 with probability of 0.00 which is less than 0.05 level set for the study. The null hypothesis is therefore rejected.

## IV. DISCUSSION OF FINDINGS

The finding indicated that there was no significant difference in the mean achievement of male and female students taught using 5Es constructivist instructional strategy. This finding agrees with that of Okoh, Iwuozor and Odinma (2011) who found no significant difference in the mean achievement scores of male and female students. The finding also corroborates Nwagbo and Obiekwe (2006) who found that when boys and girls were given equal opportunity, they perform equally better. This result however, contradicts the findings of Adagba (2013) who found that male students perform better than female students when taught using laboratory strategy in Chemistry. The success of both male and female students in achievement in chemistry in this study could be attributed to the equal learning opportunities provided by the use of 5Es constructivist instructional approach.

In 5Es constructivist instructional approach classes every student is given an opportunity to elaborate his/her ideals, carry out practical activities and evaluate his/her findings which could enhance achievement by all students irrespective of gender. As Gyuse (1990) contended, the determinant factors of students' achievement in science are a complex function of a child's innate ability; cognitive ability on one hand and environmental influences of both home and school on the other hand. Thus, this result of no significant difference in the achievement of male and female students could be as a result of equal classroom interaction/participation opportunities provided by the 5Es constructivist instructional approach for both male and female. This implies that if male and female students are given equal opportunities in the learning process using innovative teaching methods such as 5Es constructivist instructional approach, the educational inequality in terms of gender differences especially in science may be narrowed.

It was also found in this study that there was a significant difference in the mean retention scores of male and female students taught Chemistry using 5Es constructivist instructional approach. The female students have a mean retention scores higher than that of the male students. This finding is consistent with the views of Mari (2002) who found that there were significant differences in cognitive ability in respect to gender. The finding however disagrees with Ikedolapo and Adatunji (2009) who found no significant difference in the mean retention scores of male and female students who were taught chemistry using constructivist instructional strategy. This finding implies that if female students are given equal opportunity with their male counterpart they may even do better in chemistry than the male students.

## V. CONCLUSION

It is concluded in this study that the use of 5Es constructivist instructional approach enhances students' achievement and retention in Chemistry. With the use of 5Es constructivist instructional approach there was no significant difference between male and female achievement in chemistry. This implies that if chemistry teachers use innovative teaching methods such as the 5Es constructivist instructional approach which is found to enhance students' achievement, the issue of poor achievement in Chemistry at the senior secondary level may be a thing of the past. Similarly, the gender gap created by continued use of lecture method in teaching science could also be bridged with the use of 5Es constructivist instructional approach.

## VI. RECOMMENDATIONS

Base on the findings, the following recommendations are made:

1. Chemistry teachers should use 5Es constructivist instructional strategy which provides students opportunity to interact with materials, teachers and peers and enhance their achievement and retention.
2. Educational stakeholders (Ministry of education, Teachers' Service Board, Universal Basic Education Board, UNICEF etc.) should organize workshop for retraining of in-service teachers on the use of 5Es constructivist instructional strategy.
3. Where there is gender gap in achievement and retention, selection and use of 5Es constructivist instructional strategy could help narrow the gap..

## REFERENCES


[1] Adagba, M. M. (2013). Comparative effects of laboratory and discussion methods on senior secondary two students' achievement in chemistry. *M.Ed Dissertation of the Benue State University, Makurdi.*

[2] Agogo, P. O. & Naakaa, D. A. (2014). effects of 5es constructivist instructional strategy on students' interest in senior secondary genetics in gwer local government area, Benue state, Nigeria. *Global Journal of Environmental Science and Technology*, 1(2) 015-019.

[3] Aguele, G. A. & Agwuga M. O. (2007). Effect of cooperative learning teaching strategy on the reduction of students' anxiety for learning chemistry. *Journal of Turkish Science Education 7 (1). Retrieved on 23/4/2013 from http://www.tused.org*.

[4] Akem, J. A. (2007). *Research and statistics for higher education.* Makurdi: Destiny Ventures.

[5] Albert, H.G. (2000). Methods enhancing children interest and mastery orientation. *Learning of Individual Differences, 25, 171 – 177.*

[6] Ameh, O. C. & Dantani, M.G.(2012). Effect of small group instructional techniques on chemistry achievement of SSS slow learners. *Amadu Bello University Journal of Science,* 2 (2), 23-28.

[7] Ango, M. L. (2002). Mastery of science process skills and their effective use in the teaching of science: An educology of science education in the Nigerian context.*International Journal of Educology,16(1), 12-30.*

[8] Ausubel, D. P. (1968). *Educational Psychology. A Cognitive View*. New York: Holt Rinehart and Winston.

[9] Bruner, J. (1966). Stages of representation. Retrieved on 23/4/2014 from http//:www.youtube.com/watch/edu/brunertheory.

[10] Chianson, M. M., Kurumeh, M. S., & Obida, J. A. (2010). Effect of cooperative learning strategy on students' retention in circle geometry in secondary schools in Benue State, Nigeria. *American Journal of Scientific and Industrial Research,* 2(1), 33-36.

[11] Ezenwa, G. N. (2003). The relative effect of meta-cognitive strategy of framing on students' achievements in selected difficult chemistry concepts. *Journal of the Science Teachers Association of Nigeria,* 37(1&2), 20-28.

[12] Hassard, G. W. (2006). Constructivist model for learning. Retrieved on *20/'04/2013* from *http://www.ncrel.org/sdrs/areas.*

[13] Igboko, K. O., & Ibeneme, O. T. (2006). Effects of some cognitive constructivist instructional approaches on students achievement and retention in the study of introductory technology in Nigeria. *Journal of Science Teachers Association of Nigeria*.41, (1& 2), 43-47.

[14] Longe, C. N., & Adedeji, M. O. (2003). Effect of cooperative learning teaching strategy on the reduction of students' anxiety for learning chemistry. *Journal of Turkish Science Education, 7 (1), 41-45*.

[15] Madu B. C. & Ezeamagu, M. U. (2013). Effect of constructivist based approach (5es) on the pupils' achievement in primary mathematics in Enugu state, Nigeria. *International Journal of Educational Science and Research 2(1) 23-31*.

[16] Mari, J. S. (2002). Gender related difference in acquisition of formal reasoning schemata: Pedagogic implication of teaching chemistry using process- based approach. *Journal of the Science Teachers Association of Nigeri,* 37(1&2), 76-81.

[17] Ogbu, J. E. (2011). Effect of investigative application of interaction pattern on cognitive achievement in basic electricity. *Journal of Science Teachers Association of Nigeria, 46(1), 73-77.*

[18] Okebukola, P. A. (2006). Students performance in practical chemistry; A study of some factors related factors. *Journal of Research in Science Teaching,* 24 (2),119-216.

[19] Ortese, P. T., Yawe, A., & Akume, G. T. (2005). *Psychology of learning.*Makurdi: Danat Production.

[20] Samba, R. M. O. & Eriba, J. O. (Eds.) (2012). *Innovative approaches in teaching difficult science concepts.* Makurdi: Destiny Ventures.

[21] Sara, B. (2003). The constructivist learning model towards real reform in science education. *Retrieved on 20/'04/2013 from http//.www.collegetermpapers.com*.

[22] Tsoho, L. T. W. (2010). Effects of problem solving and student centered teaching strategies on students'geometry performance and retention in junior secondary schools in Kano State**.** *An Unpublished M.Ed. Dissertation of the Ahmadu Bello University, Zaria*.

[23] Uwague and Ojebah (2008). Chemistry education: A scientific approach for national development. *Proceeding of the 31st annual interactional conference and exhibition of chemical society of Nigeria, 653-656.*

[24] Vygotsky, L. S. (1924). Methodology of reflexological and psychological research.Retrieved on 20/04/2013 from *http://www.kolar.org/vygotsky*.

[25] West African Examination Council (2007-2011). *Chief Examiner Report in the May/June Ordinary level SSSCE.*

[26] Woolfolk, A. (2008).*Educational psychology (9th ed.).* Delhi: Pearson Education.