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Effect of 5es constructivist instructional approach on senior secondary students' achievement and retention in chemistry in Benue state, Nigeria

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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 259 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 is a significant difference between the mean achievement test scores of students taught Chemistry using 5Es constructivist instructional strategy and those taught using the lecture method in favour of those taught using 5Es constructivist instructional strategy. There is also a significant difference in the mean retention score of the of students taught Chemistry using 5Es constructivist instructional strategy and those taught using lecture method with those taught using 5Es constructivist instructional strategy having higher retention mean. 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: 5Es, chemistry education, constructivist instructional approach, achievement, retention

1. 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) [6]. Chemistry deals with the study of the composition, properties and use of matter (Okebukola, 2006) [18]. 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) [23]. Uwague and Ojebah (2008) [23] 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) [23].

Despite the importance of chemistry, students' achievement in chemistry has been very poor. Madu & Ezeamagu (2013) [22]. defined achievement as the quality and quantity of a student's work feat. Akem (2007) [4] 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) [18] 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.

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 20th 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) [17]. Poor teaching method was observed by Agogo and Naakaa (2014) [2] 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) [20] 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) [15]. 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) [5]. Ezenwa (2003) [11] 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) [18] 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) [11] 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) [20] 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) [20]. It is among these difficult topics that the efficacy of the constructivist instructional approach was investigated.

Tsoho (2010) [22] 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) [13] 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) [19] affirmed that learning cannot take place in the absence of retention. In confirming this Chianson, Kurumeh, and Obida, (2010) [10] 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) [18] 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) [18], 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) [19] 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) [24]

Constructivist learning holds that people construct their own understanding and knowledge of the world, by experiencing things and reflecting on those experiences (Vygotsky, 1924) [24]. 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) [9] called a "schema" while Ausubel (1962) [8] 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) [21]. 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) [21].

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.

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.

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. Determine if the use of 5Es constructivist instructional approach improved SS II students' achievement in Chemistry.
2. Determine if the use of 5Es constructivist instructional approach improved SS II students' retention in Chemistry.

Research Questions

The study was guided by the following research questions.

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

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 SS2 students taught chemistry using 5Es constructivist instructional approach and those taught using the lecture method.
2. There is no significant difference in the mean retention scores of SS2 students taught chemistry using 5Es constructivist instructional approach and those taught using the lecture method.

Methodology

The study adopted the non-equivalent control group, pre-test, post-test quasi experimental design. A sample of 259 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.

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 SS2 students taught chemistry using 5Es constructivist instructional strategy and those taught using the lecture method? Answer to this research question is presented in Table 1.

Table 1: Means and Standard Deviations of SS II Students' Achievement Taught Chemistry with 5Es and those taught with Lecture Method.

Group	N	Pre-test Mean	SD	Post-test mean	SD
5Es.	132	34.29	6.15	62.90	11.25
Lecture method	127	33.84	5.87	54.74	10.14
Mean Difference Total	259	0.45		8.16	

Result in Table 1 reveals that students in the 5Es constructivist group have a mean of 34.29 in the pre-test and standard deviation of 6.15 while those in the lecture method group have a mean of 33.84 and standard deviation of 5.87 with a mean difference of 0.45. In the post-test, the students' taught chemistry using the 5Es constructivist instructional strategy have a mean scores of 62.90 while those taught using the lecture method have a mean score of 54.74 with the mean difference of 8.16. The corresponding hypothesis is as presented below.

Hypothesis One

There is no significant difference between the mean achievement scores of students taught chemistry using 5Es constructivist instructional strategy and those taught using the lecture method. The test result of this hypothesis is presented in Table 2.

Table 2: ANCOVA Result of SS II Students Achievement taught Chemistry with 5Es and those taught with Lecture Method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	83805.81[a]	2	41902.90	87.27	.000	Significance
Intercept	12743.38	1	12743.38	26.54	.000	Significance
Pretest	53390.67	1	53390.67	111.20	.000	Significance
Group	33228.53	1	33228.53	69.20	.000	Significance
Error	67219.55	259	480.14			
Total	1375957.00	275			.000	Significance

Table 2 revealed that there is a significance difference between the experimented method and the lecture method as the pretest result and the group result are both having significant level of 0.00 which is still less than 0.05 set for the study and the null hypothesis is therefore rejected.

Research Question Two

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

Table 3: Means and Standard Deviations of SS II Students' Retention taught with 5Es and those taught with Lecture Method.

Group	N	Pretest Mean	SD	Retention test mean	SD
5Es.	132	34.29	6.15	60.83	11.01
Lecture method Mean	127	33.84	5.87	46.65	8.72
Difference Total	259	0.45		14.18	

Table 3 shows that in the pretest, the experimental group has a mean of 34.29 and standard deviation of 6.15 while the control group has a mean of 33.84 and Standard deviation of 5.87. their mean difference is 0.45 The result in Table 3 also shows that the 5Es constructivist instructional strategy group has a Mean of 60.83 while the lecture method group has a mean of 46.65 in the retention test with a mean difference of 14.18. The corresponding hypothesis is presented below.

Hypothesis Two

There is no significant difference between the mean retention scores of students taught chemistry using 5Es constructivist instructional strategy and those taught using the lecture method. The test result of this hypothesis is presented in Table 4.

Table 4: ANCOVA Result of SS II Students Retention taught with 5Es and those taught with Lecture Method.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	15168.87[a]	1	15168.87	19.63	.000	Significance
Intercept	1236869.29	1	1236869.29	1600.49	.000	Significance
Group	15168.87	1	15168.87	19.63	.000	Significance
Error	108965.96	270	772.81			
Total	1372127.00	275				

a. R Squared = .122 (Adjusted R Squared = .116)

Table 4 reveals that there is a significance difference between the experimental group and the control group as the group result has significant level of 0.00 which is less than 0.05 set for the study. The null hypothesis is rejected.

Discussion of Findings

The findings revealed that students taught using 5Es constructivist instructional strategy achieved higher than those taught using the lecture method. This finding corroborates Agogo and Naakaa (2014) [2]; Madu and

Ezeamagu (2013) [15] who found that achievement of students were enhanced when teachers engage students in 5Es constructivist instructional strategy. The higher achievement of students taught using 5Es constructivist instructional strategy could be attributed to their frequent engagement in practical activities, explanations and evaluation of concepts learnt. This finding indicated that learning opportunities provided by the 5Es constructivist instructional strategy have the capacity of enhancing students' achievement. This could be because students taught using 5Es constructivist instructional strategy actively participated in the teaching-learning process which enhanced their understanding of the concepts. On the other hand those in the lecture group achieved poorly because they were passively engaged.

The findings also indicated that students taught chemistry using the 5Es constructivist instructional strategy have a greater mean retention scores than those taught using the lecture method. This findings corroborates that of Igboko and Ibeneme (2006) [13]; Liga (2014) who found that students taught using constructivist instructional strategies retained the knowledge more than those taught using lecture method. The reason for the better retention of students taught using 5Es constructivist instructional strategy could be because students were captivated, more focused, attentive and interested in the learning activities they were doing. This no doubt offers anchorage for the new knowledge to be retained. This also agree with the ideals of Ausubel's (1962) [8] subsumption theory which provides that the availability of anchoring ideas facilitates meaningful learning and retention.

Conclusion

It is concluded in this study that the use of 5Es constructivist instructional approach enhances students' achievement and retention 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.

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.

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