academicJournals

Vol. 12(7), pp. 456-466, 10 April, 2017
DOI: 10.5897/ERR2016.3095
Article Number: BA7D46563683
ISSN 1990-3839
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Educational Research and Reviews

Full Length Research Paper

The effect of learning cycle constructivist-based approach on students' academic achievement and attitude towards chemistry in secondary schools in north-eastern part of Nigeria

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Received 18 November, 2016; Accepted 17 January, 2017

This study investigated the effect of learning cycle constructivist-based approach on secondary schools students' academic achievement and their attitude towards chemistry. The design used was a pre-test, post-test non randomized control group quasi experimental research design. The design consisted of two instructional groups (learning cycle group and lecture group), two attitudes (positive and negative) and repeated testing (pre-test and post-test). The samples of the study comprised 120 students from four mixed senior secondary school class II (SS II) randomly drawn from the population. The instruments used in collecting data were chemistry achievement test (CAT) and chemistry attitude scale (CAS). The data were analyzed using mean, standard deviation and analysis of covariance (ANCOVA) used to compare the positive and negative attitude with the experimental group on academic achievement. The findings of the study indicated that learning cycle had a significant effect on students' achievement in chemistry, students taught with learning cycle significantly achieved better in chemistry Post-test than those taught with lecture method, and a non-significant difference existed in academic achievement between students with positive and negative attitude after treatment. It was concluded that learning cycle method seems an appropriate instructional model that could be used to solve the problems of science teaching and learning since it enhances students' achievement, facilitates learning and its effectiveness is not limited by attitude.

Key words: 5E Learning cycle, constructivist approach, academic achievement, attitude.

INTRODUCTION

Chemistry is taught in most schools as an abstract subject without much emphasis on practical experiences (Ghassan, 2007). This has resulted to students' low acquisition of science processing skills which has become more evident in the mass failure of students in the subject in public examinations. All the questions asked to test the knowledge of chemistry students' in practical skills require that they demonstrate one form of

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process skill or the other. The inability of students to carry out these activities properly results in low scores in the test of practical knowledge.

The shift from the teacher-centered method of teaching science to student-centered activity based method encourages and develops in the child the spirit of inquiry. The student-centered activity method as opined by Akinbobola (2006) attempts to make students fully aware as well as understand the ways scientists work and also equip and prepare them for their possible careers in science, chemistry in particular, and process skills development.

Several studies in the chemistry education literature (Jack, 2005; Obomanu, 2012; Njoku and Nzewi, 2015; Uchegbu et al., 2016) dealt with the learning difficulties of basic concepts of chemistry at schools and some reasons given included poor teaching methodologies. Concepts formed when the ideas or thoughts are developed based on common properties of objects or events by the process of abstraction. Consequently, there is a great need to help improve chemistry students' perceived learning difficulties of chemical concepts not just for them to sail through SSCE/GCE examinations, but also for them to be aware and be appreciative of the contributions they can make to the country's development. Available evidence from West African Examination Council and some science educationist (WAEC, 2014, 2015; Jack, 2005; Oyedokun, 2002) indicates student's poor academic achievement in chemistry. Therefore, we need today teaching and learning strategies that provide us with a wide range and advanced educational potential that will help our students to enrich their information, develop their mental abilities, acquire science process skills and train them to be innovative and novel.

Oriented to the predetermined goals and aimed to earn desirable behavior, teaching activities usually take place in the institutes of educations. Teachers therefore need to recognize learning styles based on students' learning outcomes as a basis for the development of an effective, efficient and innovative teaching and learning strategies (Healey and Jenkins, 2000). From this point of view, the researcher opined that learning cycle if used as an instructional method for teaching chemistry would be a suitable alternative for the lecture method which has dominated the science classrooms in Nigeria with the intention to improve students' achievement.

Learning cycle constructivist-based approach which is an inquiry-based teaching model is useful to teachers in designing curriculum materials and instructional strategies in science. The model is derived from constructivist ideas of the nature of science, and the developmental theory of Jean Piaget (Piaget, 1970). Constructivism is an epistemology, a theory of knowledge used to explain how we know what we know. A constructivist epistemology is useful to teachers if used as a referent; that is, as a way to make sense of what they see, think, and do. And constructivism stresses the importance of considering what is already in the learner's mind as a place to initiate instruction. Learning is regarded as an active process whereby students construct personal meaning of the subject matter through their interactions with the physical and social world. It is the student who makes sense out of the experiences. The learning process is facilitated by the skilled teacher who engages students in thinking, questioning, testing ideas, explaining, and representing ideas. The teacher should have good subject-matter knowledge and be flexible in their teaching methods. Constructivism also concentrates on building knowledge and claims that meaning remains subjective by the cognitive organ of the learner and is not transferred from teacher to learner. It is also interested in arousing the learner's thinking and makes him/her active, interactive and positive during the learning process.

The 5E learning cycle based on constructivist approach help increases students' critical thinking skills and also targets at the discovery and the students' acquaintance with previous knowledge of new concepts. 5E learning cycle as opined by Wilder and Shuttleworth (2005) motivates students through several phases of learning, to explore a subject, to have a given definition for their experiences, to obtain more detailed information about their learning and to evaluate it. Learning using the learning cycle method is an active cognitive process, in which the student goes through various, explorative educational experiences which enable him to explore the knowledge intended to be taught. The learner engages in a mental activity represented by the re-organization, re-arrangement and alternation that the learner introduces to the learning material.

Consequently, learning using the learning cycle strategy is indeed a meaningful learning that increases learner's educational achievement. Students do a mental activity to solve a number of problems in the process where the 5E learning cycles model is used. Working in pairs or in groups of three, students ask questions, and they share their opinions in response to explanations offered as answers to the questions. Students' answers to open-ended questions help to uncover their misconceptions. Recording the data gathered for the whole class by using all facilities of technology with experiments and observations assures that students make a comparison of their data with others' by going through a mental process and that they inquire the aspects that their data agree and disagree with others' data. Thus, students' scientific process skills begin to develop. Besides, it also becomes possible for students to use the materials they are familiar with, that is to say, to associate their new experiences with their previous experiences and to structure the knowledge (Colburn, 2007).

More also, Campbell (2000) observed that 5E learning cycle is one of the complete constructive models used in classrooms and it is a learning that is research-based or brain-storming where students think creatively through higher order thinking skills or critical thinking skills. The learning cycle approach facilitates learning and creates beneficial opportunities for students while learning (Lorsbach, 2006). Learning cycle strategy is also concerned with the entire content to be learnt and with the cognitive structures the learner has and also deals with the selection and organization of content experiences in order to facilitate the material to be learnt within learner's cognitive structures and create new knowledge structures to bring about cognitive development. Furthermore, this method is concerned with increasing learner's motivation towards learning, a thing that increases achievement and stresses the importance of practice, which helps to learn actively in order to acquire science process skills.

The 5E learning cycle model assures that students are active in classes, they have the opportunity to research and analyze, and that they reach knowledge by creating discussion environments and by continuously inquiring (Gunduz-Bahadir, 2012). Learning cycle also helps the learner to evaluate themselves, and to reach a formula of what he understood of relationships that connect concepts, details, models and applications. This model is an opposite of the traditional method which deals only with the learning material and gives it an absolute importance in the teaching and learning process, where the teacher plays a fundamental role; and this will eventually lead to a memorizing learning without observing individual differences amongst learners.

The learning cycle used in this study was hinged on Bybee's (1997) 5E learning model (Engagement, Exploration, Explanation, Elaboration and Evaluation). According to Bybee (1997), the foundation of this model was affected by works of German philosopher Freidrich Herbart. Furthermore, in his view, this model is based on the ground of John Dewey and Jean Piaget. As a very frequently used model in constructivist learning approach, 5E learning cycle model's name comes from the number of its phases and the initials of each phase. These five phases are: Engagement, Exploration, Explanation, Elaboration and Evaluation. The description of each phase of the learning cycle is hinged on the works of Kilavuz (2005), Wilder and Shuttleworth (2005), Moyer et al. (2007) and Ahmed (2012). The descriptions of the events that take place at each stage are discussed as the following.

Engagement

Engagement stage is designed to help students understand the learning task and make connections between learning experiences. The purpose of this phase is to focus students' attention on the topic. In this phase, past experiences are connecting with actual experiences. The basis of work for upcoming activities is organized. In this stage teacher create interest and generate curiosity in the topic of study. For this reason activities are made. These activities help students to make connections with the previous knowledge. Teacher raises questions and elicits responses from students that will give you an idea of what they already know. Teacher has also a good opportunity to identify misconceptions in students' understanding.

Exploration

In exploration stage, students should also be given opportunities to work together without direct instruction from the teacher. Students get directly involved with phenomena. The teacher's role in the exploration phase is that of guide, coach and facilitator. Students should be puzzled. This is the opportunity for students to test predictions and hypotheses and/or form new ones, try alternatives and discuss them with peers, record observations and ideas and suspend judgment.

Explanation

The explanation phase is a teacher-centred phase in 5E model, because teachers become active for correcting mistakes and completing the missing parts in students' results. Teachers may choose lecture method or may use another interesting method like showing a film or a video, making a demonstration or giving an activity which leads students to define their work or to explain their results. In this phase, teachers give formal definitions and scientific explanations. Furthermore, by giving explanations in basic knowledge level to students, teachers, whenever possible, help them to unify together their experiences, to explain their results and to form new concepts (Bybee, 1997). In this phase, mistakes noted in students' during lesson can be corrected before the next phase.

Elaboration

In the "Elaborate" stage, students expand on what they have learned and apply their new found knowledge to a different situation. During "Elaboration", students should also apply concepts and skills in new (but similar) situations and use formal labels and definitions. Students expand on the concepts they have learned, make connections to other related concepts, and apply their understanding to the real world around them. This phase often involves experimental inquiry; investigate projects, problem solving and decision making. The teacher may decide to recycle through different phases of the 5E learning cycle to improve students' understanding or move on to new science lessons. Working in groups also in this phase, students are close to end up the asked problem. The groups present and explain their final situations. The elaborate phase is important because the new learned is corroborated and its permanence is supported.

Evaluation

The learning cycle provides opportunities for the instructor to continually observe students' learning and to monitor their progress using questioning techniques and discussions. More formal evaluation can be conducted at this stage. The assessment should be aligned with the styles and content of the learning experience. The multiple choice quizzes were designed and used primarily for assessing changes in student understanding as part of the evaluation of the materials. Evaluation should take place at all points along the continuum of the instructional process. Students should assess their own learning. Teacher asks open-ended questions and look for answers that use observation, evidence, and previously accepted explanations. Students are also asked questions that would encourage future investigations. This phase reveals how students constructed scientific knowledge and they generalize or relate it to other situations (Wilder and Shuttleworth, 2005).

Literature on the effects of 5E learning cycle on academic achievement and attitude are scanty and limited. Studies by Whilder and Shuttleworth (2004) and Ceylan (2008) found significant differences in achievement between the experimental (treatment) and control groups in favor of the experimental group. Studies by Ajaja (2013), Ajaja and Eravwoke (2012), Pulat (2009), Cardak et al. (2008), Baser (2008), Nuhoglu and Yalcin (2006), Akar (2005), Whilder and Shuttleworth (2004) and Lee (2003) found that students' achievement improved significantly after the usage of 5E learning cycle during classroom instructions. Specifically, Lee (2003) found that the students acquired knowledge about plants in daily life easier and understood the concepts better when taught with learning cycle.

The results of empirical reviewed literatures (Ahmed, 2012; Kilavuz, 2005) revealed the effectiveness of the learning cycle on the educational results like achievement, scientific attitudes and thinking skills in all levels. These appeared to be the fundamental objectives of the scientific education, and had made great strides in the educational field as an effective teaching strategy due to its harmony with the nature of science, attainment of scientific knowledge, acquisition of science and thinking skills; and also because it attaches great importance to the learner.

Over the years, the teaching of science and particularly chemistry has been based on lecture method. The results of chemistry students as noted in the chief examiners report as measured by their grades in the senior school certificate examinations have not shown any significant improvement (WAEC, 2012, 2013, 2014). This development indicates an instructional method failure and ineffectiveness which calls for a more effective, efficient and innovative instructional strategy such as learning cycle. Furthermore, the learner's formation of meanings is an active psychological process which demands mental effort. It also concentrates on the learner and his/her activity during learning, and emphasizes meaningful learning based on understanding through the students' active role and effective participation in the activities they do, in order to build their concepts and scientific knowledge. For this reason, the present study aimed to examine the effectiveness of "non-metals concepts" instruction based on 5E learning cycle model and attitudes toward science as a school subject. Students' attitudes, feelings and perceptions of science are also important for science achievement. Understanding the non-metals such as hydrogen, chlorine, oxygen nitrogen, etc., in the periodic table are critical for learners since these topics serve as the foundation for understanding gases which are very useful to man in her immediate environment through a purposeful activity.

This instructional method failure and ineffectiveness accompanied with students' poor academic performance and science process skills acquisition is a gap that exists in literature in chemistry education in the Nigeria and north-east in particular. This gap needs to be filled to enable researchers and science teachers fully appreciate the roles and effects of this instructional strategy in the teaching and learning of sciences. The statement of the problem therefore is, will the application of learning cycle method in teaching and learning of chemistry produce similar effect on students' achievement, create positive attitude in students' towards chemistry, promote science process skills acquisition, and help eradicate students learning problems in Nigeria? Therefore, this study aimed to investigate the effects of 5E Learning Cycle based on the constructive approach on students' achievement and attitudes towards chemistry as a subject.

Research questions

To guide this study, the following research questions were raised and answered:

(1) Is there any difference in chemistry achievement among students taught with learning cycle and lecture methods?
(2) Is there any difference in chemistry achievement

between students' with positive and negative attitude taught with learning cycle and lecture methods?

MATERIALS AND METHODS

Research design

The design used for the study was a pre-test, post-test non randomized control group quasi experimental research design which consisted of two instructional groups (learning cycle group and lecture group), two attitudes (positive and negative) and repeated testing (pre-test and post-test). The independent variables were two different types of instructional approaches; instruction based on 5E learning cycle model and lecture method (traditionally designed chemistry instruction) while the dependent variables were students' understanding of chemistry concepts (non-metals) and their attitudes toward chemistry as a school subject.

Samples and sampling technique

The samples consisted of four mixed senior secondary schools, four chemistry education graduate teachers who have taught chemistry for at least five years, four senior secondary school class II (SS II) science classes, that is, one class per school and 30 students (an average age of 16 years) drawn from 4 public secondary schools selected from the north-eastern part of Nigeria with a total sample size of 120 students. The selected schools for the study which was done randomly using balloting were first considered for selection after due consideration of some parameters which included a well-equipped chemistry laboratory as well as trained and experienced chemistry teachers. So, schools without laboratories were isolated from the study.

Instruments

Three major instruments were used for the study. The instruments included: (i) A four weeks instructional unit on non-metals (Hydrogen, Oxygen, Chlorine and Nitrogen) which is an SS II (11th grade) topic in chemistry syllabus; (ii) chemistry achievement test (CAT) which consisted of 30 multiple choice test items constructed by the researcher and drawn from the 4 weeks instructional unit; and (iii) chemistry attitude scale (CAS).

Chemistry achievement test (CAT)

This test developed by the researcher. The test contained 30 multiple choice questions. Each question had one correct answer and four distracters. The items used in the test were related to non-metals concepts. During construction of items, care was taken to eliminate any extraneous factors that might prevent the students from responding and the items that measure achievement of the specific learning outcomes were used. During the developmental stage of the test, the instructional objectives of non-metals concepts were determined to find out whether the students achieved the behavioral objectives of the course and present study. The items in the test were chosen according to the instructional objectives and were designed in such a manner that each of them examines students' knowledge of non-metals (hydrogen, nitrogen, oxygen and chlorine) concept. This test was administered to students in both groups as a pre-test to ascertain students' understanding of non-metals concepts at the beginning of the instruction. It was also administered to both groups as a post-test to compare the effects of two instructions (learning cycle method and lecture method) on understanding of non-metal concepts.

Chemistry attitude scale (CAS)

This scale was developed by the researcher to measure students' attitudes toward chemistry as a school subject. This instrument consisted of 30 items in 4 point Likert type scale (strongly agree, agree, strongly disagree, disagree). This test was administered to all students in both groups as a pre-test and post-test.

Validity of instrument

Expert opinion was obtained from chemistry educators and science education lecturers so as to attain content validity. The items were assessed by a group of experts in science education and chemistry and for the appropriateness of the items for the purpose of the investigation and representativeness of the non-metals unit of chemistry course. The classroom teachers from the schools used for this study also examined the test items to check whether they are appropriate to the instructional objectives or not. The required modifications were made in accordance with experts' recommendations and after reliability analyses, item discrimination and item difficulty indices. In consequence, Cronbach Alpha internal coefficient was calculated as 0.78 for 30-question CAT test. For each stage of the questions, the correct answers given by students were coded as "1" and incorrect answers as "0". If students' answered one of the stages correctly and the other incorrectly, again they received "0" for their incorrect answer.

Reliability of instrument

The instruments' reliability was determined by adopting the Kuder-Richardson 21 formula. This involved the management of the CAS and 30-item 4-Likert scale questionnaire and CAT with 30 items for 45 SSII chemistry students, who were not part of the study. The data was analyzed using Cronbach Alpha and Kuder-Richardson 21 formula, a reliability index with reliability coefficients of 0.75 and 0.78 for CAS and CAT, respectively; which proved that the instrument was reliable and thus suitable for the study. The CAS was used in grouping the students into positive and negative attitude; students whose mean scores were > 2.5 as positive while < 2.4 as negative.

Treatment

The treatment used in this study was modified from that of Bybee (1997) and Kilavuz (2005). This study was conducted approximately four weeks during the 2015/2016 session with students drawn from four senior secondary schools in Jalingo. 120 SS II (11th grade) students (60 males and 60 females) with an average age of 16 years from four classes of a chemistry course were used in the study. The unit "non-metals" used in this study was an SS II topic in the Nigerian chemistry curriculum which included abstract and theoretical concepts; for this reason, students have difficulty in understanding the concepts. So, while teaching non-metals concepts, the teachers made the scientific concepts as concrete as possible. Children's prior knowledge of phenomena is an important part of how they come to understand school science; therefore, the teachers were also more sensitive to children's prior knowledge before instructions.

There are two groups in the study. One of the classes was assigned as the experimental group applied 5E learning cycle model and the other class was assigned as the control group applied lecture method (traditionally designed instruction). The instructional methods were randomly assigned to the classes. Both of the groups were instructed by the same science teacher and students in two groups were exposed to same content of the chemistry course for the same duration. The classroom instruction of the groups was regularly scheduled as three times per week in which each teaching session lasted 40 minutes. The topics related with non-metals concepts were covered as a part of the regular school curriculum.

The learning cycle approach emphasizes the explanation and investigation of phenomena, the use of evidence to back up conclusions and the designing of experiments while the traditional approaches emphasize the development of skills and techniques, the receiving of information, and the knowing of the outcome of an experiment before doing it. In order to avoid bias that might distort the result of the study, the researcher ensured that students in experimental group did not interact with students in control group; the teacher who applied the treatment was not biased; the tests were administered under standard condition; and all the students gave accurate and sincere responses to all items in the instruments used in the study.

The teachers (research assistants) from the four schools who led the lessons were trained for a period of one week about the implementation of the constructivist strategy before the treatment. In order to verify the treatment, the researcher observed instructions in both groups randomly. This study was done using a pre-test and post-test control group design with CAT and CAS, which were distributed to measure students' attitudes toward chemistry as a school subject. In addition to this to avoid bias, at the beginning of the treatment all students were oriented and tested on their practical skills.

In the control group, lecture method (traditionally designed instruction) was administered as regular chemistry courses because it was teacher-centered that is the teacher transferred their thoughts and meanings to the passive students. The teacher provided information without considering students' prior knowledge and checked whether students have acquired it or not. The students were instructed with traditionally designed chemistry texts. During the classroom instruction, the teacher used lecture and discussion methods to teach science subjects where the students listened to their teacher, took notes, studied their textbooks and completed the worksheets. Each worksheet consisted of one or two pages that included questions to be answered, tables to be completed or space for students to make sketches. The teacher moved round the class during the lesson, answered some questions and made suggestions when needed. Worksheets were corrected and scored in the classroom. Then the students investigated their sheets after correction. The students were not given any opportunity to develop their thinking, reasoning and communication skills. They only received the teacher's instruction while lecturing. They were not given opportunity to use problem-solving skills in other situations. Since the teacher instructed the lecture, students in control group did not have so many chances to discuss or share ideas with each other. There was no interaction between teacher and students, and students and students in control group. They did not become more confident in their understanding of science.

Student in the experimental group were instructed with the 5E learning cycle model based on Bybee's (1997). According to this strategy, the five phases were arranged in a manner that meaningful learning occurs for the non-metals concepts. Before beginning the instruction the teachers had one week training on usage of 5E learning cycle. The teacher divided the classroom into groups at the beginning of the instruction so that interaction between the students was maximized. The learning cycle constructivist-based approach adopted for the study was the Bybee's (1997) five steps: Engagement, Exploration, Explanation, Elaboration and Evaluation.

The instruction began with the "Engagement" part. As a first phase (engagement), the teacher made demonstrations and asked students some questions at the beginning of the instruction in order to create interest and generate curiosity in the topic of study, raise questions and elicit responses from students that will give you an idea of what they already know. At the beginning of the treatment, the teacher created groups of four or five student in order to maximize the interaction in class. The teacher made a demonstration by inserting a lighted splinter into the gas jar containing a gas. The students observed that the gas immediately burns with a pop sound. According to students' observations, the teacher asked a question to the class: "How would you confirm that a given gas is hydrogen, oxygen nitrogen or chlorine? Then, the students were given opportunity to think 5 to 7 minutes about questions individually and then share it with their group. Instead of interfering student's discussions about questions, teacher helped students by raising questions to find their answers. Teacher did not give answers of the questions in this phase. Then, the teacher informed the students that they will engage in a laboratory activity to help them test their answers. In this stage, the purpose of the teacher is to create interest and generate curiosity in the topic of study, raise questions and elicit responses from students that will give you an idea of what they already know. So, students had an idea about the focus of the lesson and what they would be doing by the end of this phase. The students were introduced to the topic.

As a second phase (exploration), students were allowed to discuss the question in groups by using their previous knowledge related to non-metals concepts. During these discussions, the teacher let the student manipulate materials to actively explore concepts, processes or skills. The teacher gave enough time to the students to discuss the questions with their friends. The teacher also let them write their answers to their notebooks. During the discussion, the teacher did not interfere with the students. The facilitator (teacher) observed and listened to students as they interact. After the students discussed, each group gave a common answer to the teacher. So, the teacher had an opportunity to view the students' previous ideas. The teacher gave some solutions used in daily life and how they would confirm that a given gas is hydrogen, nitrogen, oxygen or chlorine to each group. The students tried to distinguish these non-metals and they discussed the question the teacher asked in the previous step with peers. During the discussion, they had opportunity to express their ideas and saw their peers' thoughts. Each group was supposed to record their observations and ideas and give a common answer to the teacher.

In the third phase (explanation), this was based on the students' answers; the teacher explained the concept using students' previous experiences, and then presented scientifically correct explanation by using analogies and examples from daily life in order to make concepts more concrete. The teacher listened to each group's answer and explained the concept using students' previous experiences. The teacher used examples from daily life in order to make concepts more concrete. For the answer of the question asked in "engagement" phase, they explained the test of each of the non-metals and emphasizing the differences between their physical and chemical properties. At the end of this part, students were ask to summarize what they have observed about non-metals (hydrogen, nitrogen, oxygen and chlorine) both in their confirmatory test, physical and chemical properties so that they can compare them. Teacher carefully developed a specific questioning sequence that related to the new knowledge that identified the purpose of the lesson. The sequence of questions in this portion of the lesson was most important; moving from concrete to abstract and from known to unknown. The teacher also guided children's exploration of non-metals concepts while their thinking skills were probed and feedback provided.

In the elaboration part, the fourth phase of cycle, students worked in groups again and in laboratory. The purpose of the teacher was to extend conceptual understanding, practice desired skills, and deepen understanding. The purpose of this step is extending conceptual understanding, practice desired skills, deepen understanding. Students work in groups again and in laboratory. Teacher gave hydrogen, nitrogen, oxygen and chlorine solutions and other necessary materials and wanted students to compare them.

In the fifth phase of the cycle which is the last phase called evaluation, the teacher encouraged students to assess understanding and abilities; and evaluated their learning. Assessment occurred at all points along the instruction. Before presenting each new concept, the teacher asked questions which students could answer by using their previous knowledge such as How would you confirm that a given gas is (i) hydrogen, (ii) nitrogen, (iii) oxygen, and (iv) chlorine? At the end of the sessions, all the students always got the answers of the questions. The teacher also asked questions to the students during the lesson and observed them through discussions and hands-on activities. Moreover, the students are asked several open-ended and multiple-choice questions at the end of the instruction. The students had enough time to think about the answers of the questions. Later, the answers of the questions were discussed in the classroom. Evaluation is made not only at the end of the course but in the whole process (Bybee et al., 2006; Ozturk, 2013; Wilder and Shuttleworth, 2005).

Experimental group: 5E Learning cycle based on constructivist approach

Although different methods of teaching were developed to implement constructivist-based learning, science educators usually prefer the 5E instructional model (Bybee, 1997). Therefore, the 5E instructional model, a modification of learning cycle, that is, constructivist-based science teaching was used in this study (Bybee, 1997; Bybee et al., 2006).

Control group: Lecture method (Traditional Teaching Method)

The control group used lecture method (traditionally teaching method), which was teacher-centered that is the teacher transferred their thoughts and meanings to the passive students. The teacher provided information without considering students' prior knowledge and checked whether students have acquired it or not. During instruction, students listened to their teacher, took notes, studied their textbooks and completed the worksheets. The students were not given any opportunity to develop their thinking, reasoning and communication skills. They only received the teacher's instructions while lecturing. They were not given opportunity to use problem-solving skills in other situations. Since the teacher instructed the lecture, students in control group did not have so many chances to discuss or share ideas with each other. There was no interaction between teacher and students and students and students in control group.

Analysis of data

In this study, means and standard deviations of the pre-test and post-test scores for each experimental and control groups were used to answer the research questions. To verify the difference between the two means in the post-test for the instructional approaches and attitude of students towards chemistry were statistically significant, the researcher used Analysis of Covariance (ANCOVA) at significance level of 0.05. The covariate variable was pre-test. The researcher also checked to ensure that the prior conditions for statistical analysis (such as normality distribution, parallelism) were met.

RESULTS

Answering research question one

Is there any difference in chemistry achievement among students taught with learning cycle and lecture method?

To answer this research question, the means and standard deviations of the pre-test and post-test scores for each experimental and control groups were calculated as shown Table 1.

Table 1 showed that the mean of the experimental group was 47.34 and that of the control group was 39.88. The result of the analysis presented in the Table 1 therefore showed that there was a significant difference between the post-test mean scores of the students taught by Learning Cycle and those taught by Lecture Method with respect to the non-metals concepts. To verify the difference between the two means in the post-test was statistically significant, the researcher used ANCOVA and Table 2 shows the results for the covariance analysis.

Testing hypothesis one

There is no significant difference in chemistry achievement among students taught with learning cycle and lecture methods.

As shown in Table 2, the calculated probability p-value 0.000 of main effect (Instructional approach) is less than the alpha level 0.05 and is therefore statistically significant at a level lower than at 0.05; that is, at 0.05 level with significance. It could also be noted that the difference was in favour of the experimental group which were taught with 5E learning cycle approach as their level of adjustment improved in a statistically significant way.

Answering research question two

Is there any difference in chemistry achievement between students' with positive and negative attitude taught with learning cycle and lecture methods?

To answer this research question, the means and standard deviations of the pre-test and post-test scores for each experimental and control groups were calculated as shown in Table 3.

Table 3 showed that the mean of the experimental

Table 1. Mean and standard deviation of students' pre-test and post-test achievement according to Instructional strategies (Learning Cycle and Lecture method).

Group	N	Mean	Standard deviation	Mean	Standard deviation
		Pre-test	Pre-test	Post-test	Post-test
Experimental group	60	48.25	4.71	47.34	3.80
Control group	60	39.00	4.54	39.88	-3.67

Table 2. Summary of Analysis of Covariance (ANCOVA) of students' academic achievement scores according to treatment (5E Learning Cycle) and control group (lecture method).

Variable	Source of variance	Sum of squares	Df	Mean squares	F	Sig. *p≤ .05*	Decision
Instructional approach	Covariate (Pre-test)	3416.27	1	3416.27	76.39	0.000	-
	Main effect	1532.11	1	1532.11	34.26	0.000*	Rejected
	Model	4948.39	2	2474.19	55.33	0.000	-
	Error	4963.89	117	44.72	-	-	-
	Total	9912.28	119	87.72	-	-	-

Main effect (Instructional approach); Model (Learning cycle and Lecture method). *Significant at p ≤ 0.05.

Table 3. Mean and standard deviation of students' pre-test and post-test achievement according to Attitude (positive and negative) toward chemistry.

Group	N	Mean	Standard deviation	Mean	Standard deviation
		Pre-test	Pre-test	Post-test	Post-test
Positive attitude	50	45.43	1.89	44.79	1.25
Negative attitude	70	42.44	1.10	42.81	-0.73

group was 44.79 and that of the control group was 42.81. To verify the difference between the two means in the post-test was statistically significant, the researcher used ANCOVA and Table 4 shows the results for the covariance analysis.

Testing hypothesis two

There is no significant difference in chemistry achievement between students with positive and negative attitude taught with learning cycle and lecture method.

As shown in Table 4, the calculated probability p-value 0.183 of main effect (Attitude) is less than the alpha level 0.05. The result showed that differences between the means did not reach the level of statistical significance as the value of statistical p (p-value) was not significant at a level lower than 0.05. Hence, there was no significant difference in chemistry achievement between students' with positive and negative attitude taught with instructional approaches at 0.05 levels with no significance. Students in both groups showed statistically equal development in attitude toward chemistry as a school subject.

DISCUSSIONS

This study was mainly aimed to compare the effectiveness of the instruction based on the 5E learning cycle and lecture method (traditional teaching instruction) on students' understanding of chemistry concepts. According to the descriptive statistics given from the results from the findings in the study as shown in Tables 1 and 2, it can be concluded that the instruction based on the 5E learning cycle model caused a significantly better acquisition of scientific conceptions related to non-metals concepts than lecture method. Findings from the results showed that students exposed to learning cycle performed significantly better than those that used the conventional lecture method. This is because students in the learning cycle group used a student-activity oriented approach were the teacher was there just as a guide but the lecture group was a teacher-centered approach were

Table 4. Summary of Analysis of Covariance (ANCOVA) of students' academic achievement scores according to attitude (positive and negative) towards chemistry.

Variable	Source of variance	Sum of squares	Df	Mean squares	F	Sig. p≤ .05	Decision
	Covariate (Pre-test)	3416.27	1	3416.27	59.32	0.000	-
	Main effect	103.21	1	103.21	1.79	0.183*	Not rejected
Attitude	Model	3519.48	2	1759.74	30.56	0.000	-
	Error	6392.80	117	57.59.59	-	-	-
	Total	9912.28	119	87.72	-	-	-

Main effect (Attitude), Model (positive and negative). *Significant at p ≤ 0.05.

learning was not really matter to the students, making them unenthusiastic in the subject-matter.

On the other hand, in the control group where lecture method was used, it can be concluded that lecture method or traditional instruction is less effective than instruction based on 5E learning cycle model. This is because the traditional instruction was teacher-centered that is the teacher transferred their thoughts and meanings to the passive students. This might be caused the difference in the concept test scores in traditional instruction (lecture method) versus 5E learning cycle instruction. So, it can be seen that the experimental group in this study were provided for meaningful learning to be occur. After the results are assessed, it is seen that there is a significant mean difference between the experimental and control group. Both groups of students increased their understanding in the non-metals concept as expected, but the improvement is greater in the experimental group.

The result from Tables 1 and 2 supports different literatures from science educationist which indicated a general improvement on students' academic achievement taught with learning cycle. Studies by Pulat (2009), Cardak et al. (2008), Baser (2008), Nuhoglu and Yalcin (2006), Akar (2005), Whilder and Shuttleworth (2004), and Lee (2003) found that students' achievement improves after applying learning cycle approach which they opined enhances a long lasting knowledge and understanding of scientific concepts. They further stated that students are also more capable of applying their knowledge in other subject-related areas outside the original context. The result from this study also supported the findings by Ajaja and Eravwoke (2012) who observed that there was a significant effect on students' achievement in biology and chemistry that used learning cycle which made the understanding and internalization of the concepts taught easier. More also, Pulat (2009) stated clearly that learning cycle was student-activities based, where the teacher created interest and curiosity to draw the students attention and to excite them in the phase of engagement, provided opportunities for students to make them discover the topic, and create a situation of "need to know" setting the phase for explanation. Pulat (2009) also noted that the teacher ought to encourage the students to test the presented situations further in the topic in elaboration phase, also to test their knowledge and skill in the phase of evaluation. In this way, the students can be engaged in a more meaningful and permanent learning.

The findings as seen in Tables 3 and 4 implied a non-significant difference in academic achievement between students having positive and negative attitude towards chemistry as a school subject. The treatments developed similar attitude toward science. The reason why no significant difference was found in this study might be due to the fact that students have not shown more positive attitude toward science from instruction based on 5E learning cycle model may be that instructional time using this technique was not sufficient for the students to adapt and be effective in a new technique. In order to have more positive attitude, 5E learning cycle model can be used throughout the whole science concepts. Similar results were obtained in studies concerning the effects of learning cycle's model on students' attitudes (Kilavuz, 2005; Gonen et al., 2006; Nuhoglu and Yalcin, 2006; Koseoglu and Tumay, 2010; Ahmed, 2012). The results revealed the effectiveness of the learning cycle on the educational results like achievement, scientific attitudes and thinking skills in all levels, which are fundamental objectives of the scientific (chemistry) education, and which appeared to have made great strides in the educational field as an effective teaching strategy due to its harmony with the nature of science and that the subject is a scientific knowledge and research and thinking method, and also because it attaches great importance to the learner.

In short, the research gain in terms of chemistry education in Nigeria as noted in this study showed that 5E learning cycle model is an effective teaching strategy. On the contrary, traditional instruction does not seem effective in developing students' understanding of non-metals concepts. 5E learning cycle model can provide teachers with many insights into how students can learn about and appreciate science. By using this teaching strategy, there could be better understanding of non-metals concepts because it helped in improving students' achievement and also construct their views about science and develop thinking ability. Learning cycle also advances questioning/thinking skills, activates relevant prior knowledge and promotes meaningful learning. In addition, this also helped students to have more positive attitudes towards chemistry as a school subject.

Learning cycle model is also an educational model that could be used to readdress the major problems in teaching scientific knowledge. Learning cycle constructive-based approach enhance the performance of chemistry students as they are motivated and understand the concepts better through activity-oriented classroom; avoiding learning from being abstract but concrete, thereby eradicating learning difficulties. With a strong support of empirical studies (Akar, 2005; Kilavuz, 2005; Ahmed, 2012) and findings from this present study; its application or usage helped to facilitate students' effective learning and help to organize their knowledge in a meaningful way. This study therefore used the 5E learning cycle method to enable students to understand the non-metals concepts through acquiring process of knowledge acquisition, developed problem solving skills, researched knowledge within life, developed process skills, and acquired attitudes that enabled them to generalize the knowledge (Wilder and Shuttleworth, 2005).

Conclusions

The 5E learning cycle model based instruction caused a significantly better acquisition of scientific conceptions related to non-metals concepts than lecture method. The pre-test and post-test scores of CAT also showed that both 5E Learning Cycle and lecture method group's achievement was increased. Thus, it can be concluded that there was positive effect in understanding of non-metals concepts which was statistically significant. Consequently, it may be said that the students in the experimental group understood non-metals concepts better than the students in the control group, and that they had fewer misconceptions in this matter. The pre-test and post-test scores of CAT showed that both 5E Learning Cycle and lecture method group's achievement was increased. Thus, it can be concluded that there was positive effect in understanding of non-metals concepts which was statistically significant. However, the increase in learning cycle group was higher.

This study also investigated the effect of treatment; 5E learning cycle based instruction and lecture method (traditional instruction), on students' attitudes towards chemistry as a school subject. There was no significant mean difference between the students taught with instruction based on constructivist approach and traditionally teaching method with respect to their attitudes toward chemistry as a school subject although instruction based on 5E learning cycle model, focused on students' ideas, encouraged students to think about situations. The treatments developed similar attitude toward science. 5E learning cycle based instruction also helped in facilitating students' understanding of the concept non-metals, contributed to the development of scientific process skills, increased students' attitudes towards chemistry as a subject; and improved achievement in science courses. Its ability to made students discover and explore their environment thereby acquiring long lasting knowledge, and its effectiveness is not limited by attitude which made it a very suitable and positive alternative among other instructional methods for teaching/learning chemistry concepts in secondary schools. Chemistry teachers could therefore adopt learning cycle constructivist-based on teaching chemistry concepts; since it would enable them expose real life applications/experiences to students and enhance their attitude towards chemistry as a subject.

Educational implications

In the light of the findings of the present study, the following educational implications could be offered.

Many chemistry concepts are abstractive in nature which makes learning difficult. Prospective teachers should therefore be given opportunities to apply their understandings about 5E learning cycle model based on constructivist approach through in-service training.

Teachers should use instructional techniques that promote students' understanding such as: 5E learning cycle based instruction since traditional instruction (lecture method) is less effective than 5E learning cycle based instruction. With the spread of the use of 5E learning cycle activities, students' perception that science courses such as chemistry are learned by memorization can be prevented. The formation of misconceptions can be hindered by giving concrete examples for the applications of 5E learning cycle activities in real life and by working in small groups.

Teachers should be aware of students' attitudes towards chemistry since it affects students' achievement and should seek for innovative, effective and efficient student activity-oriented instructional approaches that could improve students' attitudes.

Students should also be given opportunities to design research, form hypotheses, interpret the results, and to create their own knowledge and comprehension; to help them in science process skills acquisition and better understanding of chemistry concepts.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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