EFFECTS OF 7E LEARNING CYCLE MODEL AND CASE-BASED LEARNING STRATEGY ON SECONDARY SCHOOL STUDENTS' LEARNING OUTCOMES IN CHEMISTRY

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Abstract: *The purpose of the study was to determine the effectiveness of 7E learning cycle model, which is based on constructivist theory and case-based learning (CBL), on students' achievement in and attitude to chemistry. A total of two hundred and eight (208) SSII chemistry students drawn from some selected secondary schools in three local government areas in Ibadan, Oyo state, Nigeria participated in the study. Two stimulus instruments were used: Teachers' Instructional Guide for 7E Learning Cycle Model and Teachers' Instructional Guide for Case-Based Learning Strategy. They were complemented with Chemistry Achievement Test (r=0.81), Students' Attitude to Chemistry Questionnaire(r=0.84), and Evaluation Sheet for Research Assistants. The study adopted pretest, posttest, control group, quasi-experimental design. Two hypotheses were tested at 0.05 level of significance and data collected were analyzed using analysis of covariance (ANCOVA). Multiple classification analysis (MCA) was used to present the magnitude of the mean scores while Scheffé multiple range test was used for post-hoc test to determine the source(s) of significant main effects. The results showed a significant main effect of treatment on students' achievement in chemistry ($F_{(2,207)}$ = 4.584; p<.05] and students in the case-based learning group obtained the highest chemistry achievement score ($\bar{x}$ = 9.49) followed by those exposed to the 7E learning cycle model ($\bar{x}$ = 8.40) while the conventional method group obtained the lowest ($\bar{x}$ = 7.50); there was significant main effect of treatment on students' attitude to chemistry ($F_{(2,207)}$ = 72.551; P<.05] with the students exposed to case-based strategy obtaining higher attitude mean score ($\bar{x}$ = 69.21) than those in 7E learning cycle model ($\bar{x}$ = 68.87) and the conventional group ($\bar{x}$ = 68.54).The two strategies, 7E learning cycle model and CBL, are more effective in improving senior secondary school students' achievement in and attitude to chemistry than conventional teaching strategy. However, CBL proved to be the most efficacious. Therefore, it is recommended that chemistry teachers should adopt constructivist/inquiry methods like 7E learning cycle model and case-based learning as these strategies will help students perform better in chemistry and also positively enhance the attitudes of many more students to the subject.*

Key words: learning cycle, cases, achievement, attitude, chemistry

Introduction

One of the subjects classified as a physical science is chemistry. Chemistry is the study of the composition, structure, properties, and interactions of matter. It focuses on atoms and their interactions which bring about changes in states or reactions. In Nigeria, chemistry is one of the science subjects offered at the senior secondary level**.** In some schools, it is a compulsory subject for all the arms of SS1; while in other schools, it is offered only to the science students. The field of chemistry covers such a broad range of topics such as organic chemistry, inorganic chemistry, metals and non-metals, and applied chemistry.

The reports from the West African Examination Council's Chief Examiner (May/June, 2005, 2008 & 2009) show a trend of poor results. Adesoji and Olatunbosun (2008) stated that in spite of the attempts made by researchers to improve on the teaching and learning of chemistry, the achievement of students in the subject remains low in Nigeria and discouraging (Nbina & Vico, 2010).

Table 1
Candidates' Performance in May/June Senior School Certificate Examinations in Chemistry in the Period of 2006–2012

Year	Chemistry Total Sat	Credit Passes	%
2006	308104	170670	55.34
2007	422681	194284	45.92
2008	418423	185949	44.97
2009	422091	194035	45.97
2010	365643	236059	50.70
2011	565692	280250	49.54
2012	627302	270570	43.13

Source : WAEC National Head Office, Yaba, Lagos, Nigeria

Researchers have shown that some causes of students' anxiety leading to the perception of chemistry as a difficult subject include: wide coverage of the syllabus, students' background problems, students' lack of interest in and poor attitude towards chemistry, low awareness of career opportunities, lack of teaching aids/laboratory, the abstract nature of science concepts, the teacher, traditional teaching strategies, and teacher-centered applications (Jegede, 2007; Kolomuc, Ozmen, Metin, & Acisli, 2012; Nbina & Vico, 2010). According to Caliskan (2004) methodology is the dominant factor in science teaching to achieve the goals of science education. The conventional teaching method used in teaching chemistry in many schools is a key barrier in achieving success in chemistry education.

The traditional approach for teaching chemistry is often overly simplistic and not aligned with the most recent scientific models. As a result, many students in Nigeria and even around the world lack fundamental understanding of many topics. One of the objectives for teaching chemistry is that students can use it to address scientific inquiries as well as connect chemistry to contemporary concerns such as vaccines, incurable diseases, natural disasters, power-supply, and so on. The main goal of science teaching is that students have good understanding of concepts and imbibe the ability to apply this understanding to new situations. It is also popular that science should be taught to train dynamic individuals who question the events around them and analyze ideas. The number of the questioning and non-dogmatic individuals should be increased to let technology advance in the present age.

As scientists, students should develop basic skills, knowledge, and abilities required for tackling the difficult and non-difficult issues in their environment, and they should be able to raise new questions and use scientific means of answering them which would involve organizing or participating in controlled experiments, making observations, analyzing, and taking accurate records of data (Karanovich, 2013; Nbina & Vico, 2010). Rutherford (1964) as quoted in Caliskan (2004) stated, "We need to teach science as a process or method rather than as content" (p. 3). Scientific inquiry helps to create an attitude of open-minded quest for answers to problems while applying the highest cognitive skills and engaging the student's full range of cognitive abilities.

Over time, much work has been done in researching about inquiry teaching methods hence, the derivation of new learning and teaching strategies. Among which are the 7E learning cycle model and case-based learning. The learning cycle was created by Karplus in the late 1950s and fully developed by Atkin and Karplus (1962) as *guided discovery*. "Learning cycle is the inquiry learning process pattern for learners to investigate the scientific knowledge through science process skill and to search for knowledge or significant self-learning experience based on constructivist theory" (Polyiem, Nuangchalerm, & Wongchantra, 2011, p. 258). A learning cycle is a concept of how people learn from experience. Learning cycles can serve as basis for developing instructional materials such as lesson plans, worksheets, etc. A learning cycle helps teachers to think critically and strategically in order to meet the unique needs of students.

The 7E learning cycle emphasizes examining the learner's prior knowledge for what they want to know first before learning the new content. This cycle helps make for an effective learning process through seven steps:

Elicit: Teacher extracts or draws attention to prior understandings and knowledge. New knowledge is built on existing knowledge. This assists in transferring knowledge.

Engage: This stage focuses student thinking on content providing conversation opportunities for all students, not just a select few.

Explore: Here, students get to record data, isolate variables, design experiments, create graphs, interpret results, and organize findings while the teacher checks for students' understanding.

Explain: The teacher adopts a more central role while discussing information and explaining the concepts associated with the student's exploration. Lessons during this phase introduce the students to the scientific terminology that allows them to describe their experiences, as well as provide the opportunity for students to link their experiences to the scientific concepts being explored.

Elaborate: This phase of the learning cycle provides an opportunity for students to apply their knowledge to new domains, which may include raising new questions and hypotheses to explore. This phase may also include related numerical problems for students to solve. According to Eisenkraft (2003), this stage ties directly to the psychological construct called *transfer of learning*.

Evaluate: Evaluation can be formative, summative, formal or informal. Teacher assesses the extent to which set objectives have been achieved.

Extend: This stage is actually added to elaborate with the intention to explicitly remind teachers of the importance for students to practice the transfer of learning. Teachers need to make sure that knowledge is applied in a new context and is not limited to simple elaboration.

Another important feature of the 7E learning cycle is assessment of prior knowledge. This step can help the teacher realize what the students need to learn first resulting in efficient learning on the part of the students. The 7E model ensures that eliciting prior understandings and opportunities for transfer of learning are not omitted. With a 7E model, teachers will engage and elicit and students will elaborate and extend (Eisenkraft, 2003).

Case-based learning (CBL) is a pedagogical method that uses case studies as active learning tools. A case study is composed of an engaging and/or controversial story, usually a dilemma that requires a basic understanding of scientific principles. It is also defined as analysis of a particular case or situation used as a basis for drawing conclusions in similar situations (Microsoft® Encarta®, 2009). CBL is largely used in teaching medicine, law, and psychology, and so on. Case-based learning provides an environment to enhance students' interest and enjoyment toward learning (Hereid, 2004; Yalcinkaya, Boz, & Erdur-Baker, 2012). Cases are usually composed of two main parts: (a) the case situation for the study or a story or narration of an event and (b) the questions related to the case situation. The purpose of the study questions is to direct students to facilitate their understanding, rather than simply asking for the names, dates, or labels in analyzing the data and suggesting solutions. Class discussion is facilitated by these study questions. Learners solve the presented problem using their background knowledge. Most instructors believe that it is a good way to get students to analyze data and highlight important aspects of a concept and that the approach was useful in disseminating the presentation of challenging material.

Attitude is one of the vital determinants of an individual's actions. Although there are many definitions of attitude, all the views agree that an attitude is an individual's disposition to think, feel, or act positively or negatively toward objects in his or her environment. Attitude has also been viewed as a non-observable psychological unit that can only be deduced from an expressed behavior, embracing a range of emotional behaviors such as prefer, accept, appreciate and so on (Adolpe, 2002; Welch, 2010). It is known that teachers' approach or technique within and without the classroom can influence students' learning either negatively or positively. Researchers have shown that students' attitudes towards science have a significant influence on their achievement in the subject (Prokop, Tuncer, & Chuda, 2007).
This study provides ample information that is relevant to science, science teaching, chemistry teaching, curriculum planners, educational administrators, policy-makers and planners in science education, and teacher education with respect to the inclusion of 7E inquiry model and case-based learning into the chemistry curriculum.

Hypotheses

H_{01}: There is no significant main effect of treatment on students' achievement in chemistry
H_{02}: There is no significant main effect of treatment on students' attitude to chemistry

Methodology

The research design employed in this study is the pre-test-post-test-control group quasi-experimental research design. The treatment operated at three levels: two experimental groups and one control group.

Participants and Scope

The participants were 208 senior secondary class two students from six, purposively selected senior secondary schools in three local government areas in Ibadan, Oyo State, Nigeria. Instruction was delimited to content material based on the 7E learning cycle model and case-based learning technique for teaching ionic theory, oxidation-reduction, mole concept, and electrolysis in chemistry as designed by the researcher.

Instruments

Five instruments were used in this study. They are
1. Teachers' Instructional Guide for 7E Learning Cycle Model
2. Teachers' Instructional Guide for Case-Based Learning Strategy (TIGCBL)
3. Chemistry Achievement Test(CAT)

4. Students' Attitude to Chemistry Questionnaire(SACQ)
5. Evaluation Sheet for Research Assistants (ESRA).

Pre-Treatment and Treatment Activities

Prior to the commencement of the experiment, proper approvals from school authorities and chemistry teachers were obtained. The teachers for the experimental classes were trained for a period of one week on the use of the treatment packages. For the pre-test, the Chemistry Achievement Test (CAT) and Students' Attitude to Chemistry Questionnaire (SACQ) were administered. The experimental and control groups were taught for a duration of four (4) weeks. At the end of the treatment, the same attitude test (SACQ) that was administered at the pre-test stage and a slightly reshuffled version of the achievement test (CAT) were administered to the students after their last lesson on the topic. The results were collected and analyzed in order to identify any significant difference in the learning outcomes of the student after exposure to treatment. Experimental group data were compared to those of the control group.

Data Analysis

The data collected from the experiment were subjected to analysis using analysis of covariance (ANCOVA) with pre-tests scores as covariates to determine if there were statistical main effects found and multiple classification analysis (MCA) was used to present the magnitude of the mean scores. Scheffé's multiple range test was used for post-hoc analysis to determine the source(s) of significant main effects. All hypotheses were tested at 0.05 level of significance.

Results and Discussion

Table 2 shows that there is a significant effect of treatment on students' achievement in chemistry ($F_{(2,207)} = 4.584$; $p<.05$). This means that there is a significant difference in the chemistry achievement of students exposed to 7E learning cycle model and case-based learning and those in the control group. Hence, hypothesis 1 is rejected.

Table 2 shows that group 1 – case-based learning ($\bar{x}$ = 9.49) differs significantly from the control group ($\bar{x}$ = 7.50). Also, the 7E learning cycle model strategy group ($\bar{x}$ = 8.40) differs significantly from the control group ($\bar{x}$ = 7.50). This means that there are significant differences between each of the three possible pairs of groups in the study. They all therefore contributed to the observed significant effect of treatment on students' achievement in chemistry.

Table 2
Summary of ANCOVA of Posttest Achievement Scores in Chemistry by Treatment

Source of variance	Hierarchical Method				
	Sum of Squares	df	Mean Square	F	Sig
Covariate PREACHIVT	23.526	1	23.526	22.185	.000
Main Effect (Combined)	33.482	4	837.039	310.994	.000*
Treatment	98.413	2	49.457	4.584	.011*

* Significant at p<.05

Further, in order to determine the magnitude of the mean scores of students in each of the treatment and control groups, the MCA is reported in Table 3. From Table 3, results show that students in the case-based learning obtained the highest chemistry achievement scores ($\bar{x}$ = 9.49). This group is followed by those exposed to the 7E learning cycle model ($\bar{x}$ = 8.40) while the conventional method obtained the lowest ($\bar{x}$ = 7.50). This implies that the case-based learning was more effective than the 7E learning cycle and the conventional method. The order of decreasing magnitude of the chemistry achievement mean scores of the groups is represented as case-based > 7E learning cycle > control.

Table 3
Multiple Classification Analysis of Achievement Scores According to Treatment

Treatment + Category	N	Unadjusted Deviation	Eta	Adjusted for Independents + Covariates Deviation	Beta
7E	114	-.19		-.07	
Case-based	50	.85		1.02	
Conventional	44	-.51	.15	-.97	.20

Grand mean = 8.47

It is also necessary to trace the source(s) of the significant effect of treatment obtained in achievement in chemistry. The Scheffé post-hoc analysis was therefore carried out and presented on Table 4.

Table 4
Scheffé Multiple Range Tests of Achievement by Treatment

Treatment	N	$\bar{x}$	7E	Case-based	Conventional
1. 7E	114	8.40		*	*
2. Case-based	50	9.49	*		*
3. Conventional	44	7.50	*	*	

* Pairs of groups significantly different at p<.05

Table 4 shows a significant effect of treatment on students' achievement in chemistry. This could have been due to the fact that inquiry-based strategies often provide a better platform as well as environment for more meaningful learning to take place. The strategies used in this study encourage active participation on the students' part while the teacher assumes the role of a guide and not instructor as is the case in a conventional chemistry class. Chemistry is often perceived by students as a difficult and abstract course. Therefore, any strategy that can demystify this subject is often welcomed by students. Inquiry methods allow learners to learn by themselves.

7E learning cycle model was found to have a significant effect on students' achievement probably because of two major steps that are peculiar to this strategy. This is in accordance with Eisenkraft (2003) who suggested that the *elicit stage* was imperative for understanding the students' prior knowledge in order to know what the students need to know. The other stage, which is *extend* supports the process of transfer of learning whereby students can make connections between classroom instruction and the outside world. 7E promotes the application of what is taught in class. These may have contributed to the success of this strategy in improving students' achievement in chemistry which is in agreement with other findings (Kanli & Yagbasan, 2007; Polyiem et al., 2011; Siribunnam & Tayraukham, 2009).

Case-based learning (CBL), according to the result findings of this study, also had a significant effect on students' achievement in chemistry. This finding is in line with the results of similar research (Hereid, 2004; Rybarczyk, Baines, McVey, Thompson, & Wilkins, 2001; Yadav et al., 2007) which supported the notion that case-based learning encourages critical thinking and understanding. In using cases in the form of short stories in teaching chemistry, it was observed that the students' interest was aroused. The students seemed to be motivated to learn more and they paid more attention to the teacher. A cased-based class is a very interesting class since it allows students to think and share their ideas and opinions without necessarily being 'correct'.

Results from this study also indicates that the case-based learning strategy was most effective followed by 7E learning cycle model and then the conventional strategy. This finding is perhaps due to the fact that 7E learning cycle model is more complex, somewhat 'alien,' requires more class-time, and expertise on the part of the teacher. Teachers intending to use 7E need to be thoroughly trained on how to follow the seven steps within a reasonable timeframe. Even though 7E is very efficient and more applicable in a science class, case-based learning is cheaper, requires lesser class time, and is easier to execute. Over the decades, cases or stories have been used successfully to teach subjects in the social sciences, humanities, and medicine, but its use in the teaching of chemistry is a welcome development as shown in this study.

Table 5

Summary of ANCOVA of Posttest Attitude Scores by Treatment

Source of variance	Hierarchical Method				
	Sum of Squares	df	Mean Square	F	Sig
Covariate PREATTITUDE	642.448	1	649.488	10.477	.000
Main Effect (Combined)	8922.193	4	2230.548	36.303	.000*
Treatment	8901.850	2	4450.925	72.551	.000*

* Significant at p<.05

Information in Table 5 demonstrates a significant effect of treatment on students' attitude to chemistry ($F_{(2,207)}$ = 72.551; P<.05]. This implies a significant difference between the mean attitude scores of students exposed to 7E learning cycle model, case-based learning and those in the control group. To this end, hypothesis 2 is neglected. The magnitude of the groups' means scores is in Table 6.

Table 6
Multiple Classification Analysis of Posttest Attitude Scores According to Treatment

Treatment + Category	N	Unadjusted Deviation	Eta	Adjusted for Independents + Covariates Deviation	Beta
7E	114	-.29		-.01	
Case-based	50	.86		.33	
Conventional	44	-.23	.06	-.34	.03

Grand mean=68.88

Table 6 shows that the students exposed to case-based learning strategy obtained higher attitude mean score ($\bar{x}$ = 69.21) than those in 7E learning cycle model group ($\bar{x}$ = 68.87) and the conventional group ($\bar{x}$ = 68.54) respectively. In essence, the case-based teaching strategy was more effective in improving students' attitudes toward chemistry than the 7E learning cycle model strategy and the conventional teaching strategy respectively, thus, CBL > 7E learning cycle model > conventional strategy. Further the actual source of significance obtained for treatment effect on chemistry using Scheffé analysis tests is reported in Table 7.

Table 7
Scheffé Post-hoc Tests of Attitude by Treatment

Treatment	N	$\bar{x}$	7E	Case-based	Conventional
1. 7E	114	68.87			*
2. Case-based	50	69.21			*
3. Conventional	44	68.54	*	*	

* Pairs of groups significantly different at $p<0.05$

Table 7 shows a significant difference in the students' attitude scores in 7E learning cycle model strategy ($\bar{x}$ = 68.87) and conventional teaching strategy ($\bar{x}$ = 68.54). Also, the case-based learning strategy ($\bar{x}$ = 69.21) differs significantly than conventional strategy ($\bar{x}$ = 68.54). These two combined significantly to the treatment on students' attitude to chemistry.

On the other hand, the attitudinal change between the 7E learning cycle model group ($\bar{x}$ = 68.87) and case-based learning group ($\bar{x}$ = 69.21) is not significant. This pair therefore did not contribute to the significant effect of treatment obtained in Table 7.

As seen in Table 5, the findings of this study are in contrast with the findings of Kilavuz (2005) but in line with those of Siribunnam and Tayraukham (2009) and Yalcinkaya et al. (2012) who showed that case-based learning can improve students' motivation towards learning chemistry. When students are positively motivation, they tend to get more involved in the learning process. This is probably the same for 7E learning cycle. Perhaps, the students' interests were strategy. However, case-based learning proved to be the most superior.

Conclusions

From the findings of this research work, the use of constructivist strategies such as 7E learning cycle model and case-based learning strategies is more effective in improving senior secondary school students' achievement in and attitude to chemistry than conventional teaching as elicited by the 'nouvelle' or 'strange' method of learning chemistry. Just like in most schools in Oyo state, the chemistry teachers had used the conventional teaching strategy in their chemistry classes and this strategy never improved the attitude of the students to chemistry. The researcher observed that the students showed signs of emotional attachment to the characters used in the stories. With the introduction of the 7E learning cycle model and case-based learning strategy, many students showed more willingness to learn chemistry. At the end of the study, the researcher could deduce that they have begun to like chemistry and were willing to drop the idea that passing chemistry examinations was far-fetched and unrealizable.

Recommendations

Based on the findings of this study, it is recommended that science teachers, especially those in the field of chemistry, should employ modern, practical teaching strategies such as the 7E learning cycle model and case-based learning that allow students to construct their own knowledge and actively participate in the learning process. Secondly, science teachers should be adequately equipped with the skills needed to create an environment where all kinds of students can learn meaningfully individually or in groups especially in a chemistry class. Thirdly, a review and upgrade of the chemistry curriculum is also recommended in order to accommodate the inclusions of more learner-centered teaching strategies. Educational policy makers should take into consideration the desperate need for better policy, regulations, and laws that are geared toward the attainment of more meaningful chemistry education in Nigeria. Lastly, states and federal governments should, as a matter of urgency, make sufficient provision of scientific learning materials and laboratory facilities. Science teachers should also be morally and financially motivated and encouraged to introduce newer teaching strategies especially in chemistry education.

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