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Effect of advance organizers in the teaching of Chemistry in secondary schools: A case study of Anambra State

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This study examined the effect of advance organizers on secondary school students' academic achievement in chemistry and their scientific attitude. It used the pre-test post-test control group quasi-experimental design with eighty-four senior secondary 2 (SS2) chemistry students as subjects selected from two sampled schools. Chemistry Achievement Test (CAT) and Scientific Attitude Questionnaire (SAQ) were the instruments used for collection of data. The reliability of the CAT was finally determined using Spearman-Brown Prophesy Formula which yielded a coefficient of 0.82 while the Cronbach Alpha reliability coefficient for SAQ was 0.91. Analysis of covariance (ANCOVA) was used as the statistical technique for the data analysis. The hypotheses were tested at 0.05 level of significance. The findings indicated that students taught Chemistry with advance organizers achieved better and had a higher level of scientific attitude than their counterparts taught with the conventional method. The study therefore recommended that Chemistry teachers should adopt the use of advance organizers in order to improve students' achievement and scientific attitudes.

Key words: Advance organizers, Chemistry, instructional strategy, achievement, scientific attitudes.

INTRODUCTION

It is very necessary that developing countries should grape every opportunity provided by science and technology for all-round development. United States of America is one of the developed nations that boast of so many scientific inventions, hence, it is one of the nations rated as the world power. A nation without science and technology (Chemistry inclusive) is regarded as undeveloped and backward.

Knowledge in Chemistry plays a vital role in most aspects of human life. It's applications in pharmaceutical industries has resulted in high level of good health. This has made a fundamental contribution towards control of a wide range of diseases (Ezekannagha, 2013). Knowledge in chemistry has also been applied in agriculture which made a tremendous contribution towards meeting the demand of food requirements for the ever growing human population. Other areas where skills and knowledge in Chemistry has been applied include transportation, cosmetics and beverages.

Federal government of Nigeria has realized these facts and some efforts are been made which aim at boosting the quality of science and technology education. For

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instance, secondary school Chemistry curriculum has gone through series of reforms in order to meet up with some of the country's challenges. The Chemistry curriculum ensures continuity and flow of theme, reflects depth, appropriateness and interrelatedness of the curricula contents. Emerging issues like value orientation, peace and dialogue, HIV and AIDS education, entrepreneurial skills, etc., were also incorporated into the relevant contents of the new curriculum. Activities for both teachers and learners, teaching and learning materials, and evaluation guide are also provided in the curriculum (FME, 2007).

In a nutshell, as Nigeria desires to be identified with contemporary development worldwide, it then becomes imperative to organize the contents of the Chemistry curriculum around four themes of chemical world, Chemistry and environment, Chemistry and industry, and Chemistry and life (FME, 2007).

The Chemistry curriculum is packaged with contents that lead to self-actualization by students, focuses on practical activities with emphasis on locally available materials. This will enable learners to develop the spirit of enquiry as well as achieve maximum potential in the subject of Chemistry and its various applications. This implies that whether students proceed to tertiary institutions or not, the learning of Chemistry ought to inculcate in them the scientific attitude which will be beneficial to them throughout life. Some attitudes like open-mindedness, logical thinking and objectivity will enable the students react more intelligently to the challenges they may come across in their life time. Moreover, scientific attitude is not limited to those in Chemistry but is needed by everybody for decision-making in everyday endeavour. Other scientific attitudes include patience, curiosity, suspended-judgment, rationality, skepticism, and honesty.

However, inspite of all these reforms, there seem not to be much improvement in students' performance in Chemistry. Several researchers including Okeke (2008), Orasi (2007) and Okoli (2011) have reported low academic achievement and low enrollment of senior secondary school students in Chemistry. The root of this problem may be attributed to poor instructional approach. While examining the instructional strategy factor, Oka (2008) pointed out that the type of instructional plan used by teachers determine how effective learning can be, hence good teaching makes learning more meaningful. He is of the view that poor teaching would lead to poor learning and poor performance. This demands a re-examination of instructional strategies used in teaching senior secondary school students Chemistry. There is need for chemistry teachers to shift from standardized teacher-directed instruction to a more active learning environment where students can participate actively and make use of their creative minds rather than remain passive.

Teaching approaches in which learners are actively involved would likely lead to meaningful learning and not rote learning. Some researchers have observed that most Chemistry teaching in Nigeria senior secondary schools is done by the talk-and-chalk method (Oku, 2008; Okeke, 2008). This method of teaching encourages rote learning and regurgitation of facts (Okoli, 2011). Therefore, there is a need to take a closely look at the ways Chemistry could be taught in secondary schools in order to improve performance. Advance organizer is one of such instructional strategies that encourage activity learning (Shihusa, 2009).

An advance organizer is information presented prior to learning and that can be used by the learner to organize and interpret new incoming information. It is a kind of cognitive bridge which teachers can use to help learners make a link between what they know and what is to be learnt. It can equally be referred to as a short arrangement of material introduced to the learner before the lesson.

Ausubel supports the use of advance organizer as a mechanism to help link new learning material with existing related ideas. As advance organizer is not a summary of a previous lesson rather it provides a structure for students' thinking. Advance organizers are therefore framework that enable students learn new ideas/information and meaningfully link these ideas to the existing cognitive structure. They can be in form of short stories, questioning, reading material, demonstrations, etc.

Ausubel's theory of advance organizers fall into two major categories, namely, comparative and expository organizers. Comparative organizers are used when the material resembles and differs from that which is already known (Curzon, 1990). This enable the students recognize that the topic they are beginning to learn is not completely new, but rather can be related to something they are already comfortable with. Expository organizers are used when the new learning material is unfamiliar to the learner. They emphasize context and link the essence of the new material with some relevant previously acquired concepts.

Advance organizers also include metaphor, analogy, model as well as concept maps. Graphic organizers provide a visual holistic representation of facts and concepts and their relationship within an organized frame. They can exist in many forms like flow charts, story map, Venn diagrams, sequence chain, tables, and matrix. Graphic organizers may be effectively used before instructional activities like reading or viewing a film to activate prior knowledge in order to create/provide a conceptual framework for integrating new material and encourage student prediction (Shihusa, 2009). During instruction, advance organizers enable students to actively process and re-organize information. Novak (1980) asserts that creative teaching, when done well, includes the selection and use of good advance organizers.

Curzon (1990) points out that Ausubel's own research suggests that the use of advance organizers can enhance the relationship between cognitive structure and new material, thereby facilitate teaching and learning. Nwogbo (2006) in his study demonstrated the effectiveness of using advance organizers in the teaching of Physics in secondary schools. The use of advance organizer is a highly effective instructional strategy for all subject areas where the objective is to achieve meaningful assimilation of concepts.

Mayer (1979) suggests that the most effective advance organizers are those that: allow the students to generate all or most of the logical relationships in the material to be learnt, point out relationship between familiar and less familiar material, are relatively simple to learn, and are used in situations in which the learner would not spontaneously use them.

A study by Willerman (1992) investigated the effect of advance organizers in students' conceptualization of pollution in biology. The study used concept mapping as an advance organizer and revealed that students are not passive listeners in the learning process. In the present study, teachers of the treatment groups were trained by the researcher on how to use the advance organizer teaching strategy to ensure that they successfully incorporated it in their instructional process.

Statement of the problem

The implementations of every reform in secondary school Chemistry curriculum starts in classroom where teaching and learning takes place. Effective teaching and learning of science in secondary schools in Nigeria has become a problem and needs urgent attention. This issue has been observed to be affecting students' performance adversely especially in external examinations. It was equally found out that the poor academic performance of students in chemistry is associated with the use of conventional lecture method in teaching the students. This study therefore investigated the effect of advance organizer on senior secondary school students' academic achievement in Chemistry and scientific attitudes.

Purpose of the study

The purpose of this study was to ascertain the effect of advance organizer on students' academic achievement in Chemistry and scientific attitude. Specifically, the study attempted to find out the effectiveness of using advance organizers on students' achievement in Chemistry as compared to the conventional lecture method.

Research questions

The following research questions guided the study:

(1) What is the mean achievement scores of Chemistry students taught with advance organizers and those taught with conventional approach?
(2) What is the effect of advance organizers and conventional teaching approach on students' scientific attitude?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance

(1) There is no significant difference in the means achievement scores
(2) There is no significant effect of treatment on students' scientific attitude scores

METHODOLOGY

This study adopted a pre-test post-test quasi-experimental design. The experimental group had instructions through advance organizers and the control group was taught through the conventional teaching method. The choice of this design lies on its ability to identify cause and effect relationship to treatment. The cause and effect which this study intends to establish is between the two teaching strategies and achievement/scientific attitude.
The design was equally chosen because the unit of sampling a class was already constituted and therefore, it was unethical to re-constitute one randomly. The design involved a random assignment of intact classes.

Sample and sampling technique

The sample for the study consisted of eight-four (84) senior secondary school Chemistry students drawn from two schools in Awka South Local Government Area of Anambra State, Nigeria.

Instrumentation

The instruments used for data collection are: (a) Chemistry Achievement Test (CAT) and (b) Scientific Attitude Questionnaire (SAQ)

Chemistry achievement test (CAT)

The researcher designed this instrument to measure the SS2 students' achievement in Chemistry. The CAT is made up of twenty multiple-choice items based on periodic table and chemical reactions. These items measured students' ability to identify, recall facts, interpret and apply such facts in real life situations.

The instrument was validated by three experts and their comments and suggestions were incorporated into the final draft of the instrument. The test was administered to twenty SS2 chemistry students in a secondary school not involved in the study sample. Test-retest of the instrument was done within an interval of two weeks to establish the reliability using Pearson correlation which yielded a reliability coefficient value of 0.82.

Table 1. Students' achievement mean scores and standard deviation scores.

Group	N	Pre-test scores		Post-test scores		Mean gain score
		Mean	SD	Mean	SD	
Experimental	43	8.28	4.21	13.09	4.30	4.81
Control	41	6.41	2.60	8.39	3.36	1.98

Scientific attitude questionnaire (SAQ)

The researcher designed this instrument (SAQ) in order to measure the chemistry students' scientific attitude. The instruments consist of sixteen (16) items based on the following types of scientific attitude: honesty, humility, objectivity, rationality, persistence, curiosity, open-mindedness and suspended judgment. Cronbach's Alpha was used to determine the reliability of the instrument and a reliability coefficient of 0.91 was obtained.

The construction and use of instructional materials

The researcher conducted a training programme for the classroom teachers that were involved in the study. The programme was an interactive session that lasted for three days. It aimed at acquainting the teachers with the advance organizers teaching strategy before the experimental period. A pre-test was administered to the groups then followed by the experimental period of four weeks. A post-test was administered to the groups at the end of the treatment period.
The advance organizers adopted for the study were charts, concept mapping and handout. The students in the experimental group were provided with all these advance organizers prior to classroom instruction.

They were expected to study these materials and give an explanation on what is involved in the periodic table and chemical reactions. Groups and periods, blocks elements, different families, s-block, p=bock, d-block, f-block, atomic radii and ionic radii shown in the chart and concept mapping.

In the classroom instruction, the learners were given time to say what they have understood concerning the materials given to them. Learners were expected to explain the message presented by the chart and the concept mapping. During the instructional process the learners were engaged actively in a discussion in an effort to interpret the chart and the concept mapping. The handout contained information on collision theory and types of chemical reactions. In this case also, students were required to read the text and come up with explanations concerning them.

Data analysis

The research questions were answered using mean and standard deviations. The hypotheses were analyzed using Analysis of Covariance (ANCOVA) to determine the experimental effects with pre-test scores as covariates. ANCOVA was used to cater for the initial differences among the groups.

RESULTS

The results are presented in line with the two research questions and two hypotheses that guided the study.

Research question one

What is the means achievement scores of Chemistry students taught with advance organizers and those taught with conventional method? The research question one was answered using achievement mean scores and standard deviation scores. The results are shown in Table 1.

Table 1 shows that the achievement means scores of both groups improved in their performance after the treatment, however, the means gain score for the experimental group was 4.81 while that of the control group had mean gain of 1.98 which is considerably low if compared with the experimental group. The result therefore showed that the experimental group achieved higher than the control group.

Research hypotheses one

There is no significant difference in the mean achievement scores in periodic table and chemical reaction of students taught using advance organizers and those taught with conventional teaching approach. The results for testing hypotheses one are shown in Table 2. Table 2 shows F-cal value of 3.63 for treatment which is significant at 0.031. This 0.031 value is less than 0.05 significant level set for this study. Thus, the null hypotheses are rejected. This means that there is a significant difference between the achievement means scores of students taught Period Table and chemical reaction using advance organizers and those taught using conventional teaching method.

Research question two

What is the effect of advance organizers and conventional methods on student's scientific attitude? The research question two is answered using mean scores and standard deviation. The result is shown in Table 3.
Table 3 shows the mean scores of 10.32 and 8.88 for experimental and control groups, respectively for pre-test in scientific attitude, and 14.67 and 12.13 for the post-test. The mean gain score for experimental group is 4.35 while that of the control group is 3.25. This shows that experimental group had a higher gain score than the control group.

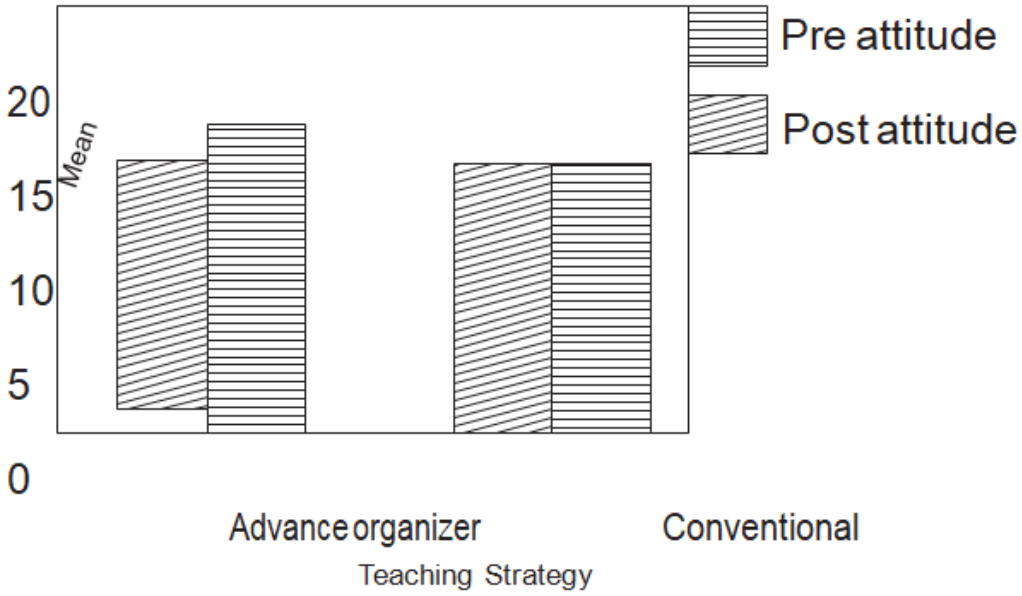

Figure 1. Comparison of pre-tet and post-test attitude scores according to treatment groups.

Table 2. Summary of analysis of covariance results for post Chemistry achievement test (achievement of mean scores with reference to method by gender). Test of Between-Subject Effects; Dependent Variable: Post-Test.

Source	Type III sum of squares	Df	Mean square	F	Sig.	Partial Eta squared
Corrected model	78.955	4	18.381	2.052	0.073	0.068
Intercept	20.714	1	20.714	2.000	0.103	0.020
Method	20.201	1	20.201	2.012	0.103	0.020
Pre-test	15.453	1	15.453	1.721	0.153	0.015
Treatment	43.301	1	43.301			
Error	878.450	101		3.628	0.031	0.043
Total	18820.000	106	8.563			
Corrected total	1011.634	105				

R Squared = 0.068 (Adjusted R Squared = 0.030).

Research hypotheses two

H_2: There is no significant effect of treatment on students' scientific attitude scores.

Figure 1 shows that the advance organizer teaching strategy improved students' scientific attitude more than the conventional teaching strategy. Therefore, Chemistry students taught with advance organizers had a better scientific attitude than those taught with conventional method.

From Table 4, the F-cal value of 3.64 for treatment is significant at 0.038 which is less than 0.05 level set for this study. This means that the null hypotheses are rejected which show that, there is significant effect of treatment on students' scientific attitude scores in Chemistry.

DISCUSSION

Table 1 shows a significant main effect of treatment on students' achievement in Chemistry. Table 2 also shows that the advance organizers facilitated learning more than the conventional teaching approach. This agrees with the assertion that the conventional teaching strategy is unproductive (Okeke, 2008) and ineffective in developing conceptual understanding of subject matter. The use of advance organizers in this study engaged learners' interest to be active cognitively. Students in the experimental group performed significantly better in the Chemistry achievement test than their counterpart in the control group. This supports the argument of Orasi (2007) that learners' active participation during instruction aids understanding and higher cognitive achievement.

Table 3. Extent of scientific attitude of students taught Chemistry using advance organizers and conventional teaching strategy.

Group	N	Pre-test scores		Post-test scores		Mean gain score
		Mean	SD	Mean	SD	
Experimental	43	10.32	2.43	14.67	3.18	4.35
Control	41	8.88	1.59	12.13	2.66	3.25

Table 4. Summary of analysis of covariance results for post-test attitude score Dependent Variable: New post attitude.

Source	Type III sum of squares	Df	Mean square	F	Sig.	Partial Eta squared
Corrected model	80.501	3	20.132	20.42	0.80	0.072
Intercept	22.304	1	22.304	2.192	0.108	0.022
Pre-test	17.510	1	17.510	2.201	0.121	0.022
Treatment	22.342	1	22.342			
Error	983.518	103		3.640	0.038	0.015
Total	18635.000	106	8.983			
Corrected total	1063.766	107				

R Squared = 0.072 (Adjusted R Squared = 0.040).

This implies that science activities tend to arouse and sustain learners' interest, make learning real and facilitate the understanding of Chemistry concepts.

In the treatment group, where there were adequate instructional Chemistry activities, the students had significantly higher post-scientific attitude mean score. This finding was applauded being that the students were exposed to these activities for only a short period. The students in the control group were not exposed to the advance organizers but to 'chalk-and-talk' method of teaching. This method is commonly used in schools for science teaching (Okeke, 2008), which does not expose students to scientific process like manipulation of instruments, measurement, formulation of hypothesis, among others. These activities tend to promote students' scientific attitude.

CONCLUSION AND RECOMMENDATION

The findings indicated that advance organizers teaching strategy is better than the conventional teaching method. The use of activity-based teaching strategy like advance organizer, make students to be more active, hence meaningful learning is achieved. This creates an environment for the inculcation of scientific attitude. Thus advance organizers enhance students' achievement in Chemistry compared to conventional teaching approach. It is hereby recommended that chemistry teachers should adopt advance organizer teaching strategy to enhance achievement in Chemistry and scientific attitude.

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