

A Meta-analysis of Effects of the Advance Organizers on Acknowledgment and Retention of Senior Secondary School (SSS) Chemistry

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ABSTRACT An investigation into the effect of pictorial and written advance organizers on students' achievement in Senior Secondary School chemistry was carried out with 138 senior secondary school two (SS2) chemistry students on the concept of energy change. The results showed that advance organizers enhance the achievement and retention of the learning materials in chemistry by the students. On the whole, pictorial organizer was found to be more effective in facilitating students' achievement and retention in chemistry than written organizer. There was no significant difference between the achievement of male and female chemistry students taught with pictorial and written organizers. It was recommended that chemistry teachers should be encouraged to adopt pictorial advance organizers in teaching the concept of energy change in chemistry.

INTRODUCTION

There can be no scientific or technological development without knowledge of chemistry. In Nigeria, efforts been made towards encouraging more students to study chemistry. Studies (Oloyede 1996; Demide 2000; Ovie-Ekpewu 2001) have shown low performance of students in chemistry. Oloyede (1996) attributed this to insufficient man power, lack of equipment, poor attitude of students and poor understanding of the concepts involved due to their difficult natures. Other reasons also included overloaded curriculum and ineffective teaching (Demide 2000).

It is, therefore, pertinent to look for variables that could be manipulated in order to find their effects on learning outcomes and to address the problems of teaching and learning of chemistry in senior secondary schools (SSS). Such variables that could be manipulated include advance organizer learning strategy (Kang 1996). An advance organizer is information that is presented prior to learning and that can be used by the learner to organize and interpret new incoming information (Mayer 2003).

The use of advance organizer to ensure effective teaching and learning in education was advocated by Ausbel (1962) in his advance organizer learning theory. This can be an appropriate instructional approach to the teaching of concepts in chemistry. Ausbel reasoned that advance organizer learning theory is a pedagogic strategy for implementing the programme principles

of progressive differentiation and integrative reconciliation which involves the use of appropriately relevant and inclusive materials that are maximally stable and discriminable from related conceptual systems in the learners' cognitive structure. It is used to provide a conceptual framework that students can use to clarify the task ahead. An advance organizer is a kind of cognitive bridge which teachers use to help learners make a link between what they know and what is to be learnt (Novak 1980). Advance organizers can refer to a relatively short arrangement of material introduced to the learner before the lesson. It is designed to cue the relevant prior knowledge of a learner and it is usually presented at a higher level of abstraction, generality and inclusiveness than that of the planned lesson (Curzon 1990). Advance organizers are therefore frameworks that enable students learn new ideas or information and meaningfully link these ideas to the existing cognitive structure (Shihusa and Keraro 2009).

Meaningful learning is explained in terms of retention. Retention is the term used to denote the demonstration that leaning has been maintained over time. It may be displayed through recognition or recall (Herron 1994).

Coffey (2000) described meaningful learning in terms of reception learning, which was a learning where the content of the learning task is presented to, rather than discovered by the learners. Meaningful reception learning involves the process of subsumption, which occurs when information enters a student's cognitive struc-

ture and interacts with and is subsumed under more inclusive concept already possessed by the student. Advance organizers work best when there is no prior knowledge involved because an advance organizer becomes the students' prior knowledge before learning the new material. According to Ausubel (1960), an advance organizer is material that is introduced before an unfamiliar content so as to facilitate its assimilation. They, therefore, act as an anchor for the reception of new content (Ausubel 1963).

The advance organizer is a strategy in which the teacher helps students to make connections between the prior knowledge and the new material. The advance organizer may be presented as written text, as graphics organizer, it may utilize audiovisual supports, or may be presented orally (Luten et al. 1980).

Statement of the Problem

Evidences of poor performance and declining enrolment point to the fact that the most desired technological, scientific and engineering application of chemistry cannot be sustained (Oloyede 1996; Demide 2000). The implications consist in the fact that chemistry teaching does not lead to students understanding of concepts, functionality and application of its ideas, hence any learning.

This makes it imperative to search for an approach for teaching of chemistry that aims at understanding rather than memorizing and juggling of facts. This study is, therefore, designed to find out the effects of pictorial and written advance organizers on the achievement of SSS two students in chemistry, as a measure towards ensuring appreciable achievement and retention in chemistry learning.

Purpose of the Study

The purpose of this study is to investigate the effects of pictorial and written advance organizers on the achievement and retention of SSS in chemistry.

The specific objectives are:

1. To investigate the extent to which the use of advance organizers (pictorial and written) will enhance the achievement of chemistry students.
2. To examine the extent to which the use of advance organizers (pictorial and written)

will enhance the retention of chemistry students.

3. To compare the achievements of male and female chemistry students taught with pictorial and written organizers.

Hypothesis

The following hypotheses were formulated and tested:

1. There is no significant difference in the achievement of chemistry students taught with pictorial organizer, written organizer and those not taught with advance organizer.
2. There is no significant difference in the retention ability of chemistry students taught with pictorial organizer, written organizer and those not taught with advance organizer.
3. There is no significant difference in the achievement of male and female chemistry students taught with pictorial and written organizers.

METHODOLOGY

The study was conducted with senior secondary school students in Bauchi, Bauchi state of Nigeria between February and March 2009. The population was made up of all the SS 2¹ chemistry students in five senior secondary schools in Bauchi Local government area of Bauchi State. The total population was 1,167 students but only one hundred and thirty-eight (138) students took part in the study. The research design adopted for the study was 3 x 2 factorial designs. There are three (3) levels of experimental factors and two (2) levels of gender. The Criterion sampling technique was used in to select schools from the target population. The criteria are:

- i. Schools that have at least one graduate chemistry teacher with at least three years of teaching experience.
- ii. Schools that have well-equipped and functional chemistry laboratories

Five (5) schools met the above criteria. Random sampling technique was used to assign students to treatment and control groups. Three schools were used as experimental group while two schools were used for control group. A researcher made Chemistry Achievement Test

(CAT) comprised of fifty (50) multiple – choice items in concept of energy change was used to obtain data for the study. Validity of the items was done by three chemistry teachers and two chemistry lecturers. The average difficulty discrimination indices of the CAT items were 0.59 and 0.52 respectively. A pilot study was conducted using fifty (50) students from a school not involved in the main study. Using Kuder Richardson coefficient of internal consistency, a reliability value of 0.86 was calculated for the CAT items. The pictorial organizer package was developed by the researcher and consisted of various maps, pictures and charts related to the concept of energy in terms of forms of energy, sources of energy, conversion of energy and application of energy conversion which served as subsume for the learning of energy changes. The written organizer consisted of the same contents with pictorial organizer but was presented in written form.

PROCEDURE

In order to account for possible pre-existing differences in overall ability between the groups, pretest was administered to two groups and the results were used as covariate measures. In order to control for the teacher quality variable, both groups were then taught by the research assistants (chemistry teachers in each school). The research assistants were trained and they were also provided with detailed instruction and well-articulated lesson packages on the concept of energy changes. The experimental group 1 was taught with pictorial organizer while the experimental group 2 was taught with written organizer. The control group was taught without advance organizers. The experimental and control groups were taught the concept of energy change using the same content outline for four weeks. The post-test was administered

to the two groups after treatment. Three weeks after the post-test, retention test was administered to the two groups

The data collected were analyzed using t- test, Analysis of covariance (ANCOVA) using pre-test scores as covariates and multiple correlation analysis. All hypotheses were tested at $P=0.05$ levels of significance.

RESULTS

This study was designed to improve student's achievement and retention in chemistry using pictorial and written organizers. The results showed that the use of advanced organizers improve student's understanding and retention in chemistry by 63 percent. Pictorial organizer was the most effective in facilitating student's achievement in chemistry. Analysis of the results of each hypothesis is thus presented.

Hypothesis one ($H_0 1$): there is no significant difference in the achievement of chemistry students taught with pictorial organizer, written organizer and those not taught with advance organizer.

From Table 1, it is seen that the main effect was significant at $P < .05$. The calculated F-value 108.39 is greater than the critical F-value of 3.92; therefore the null hypothesis was rejected consequent upon the existence of significant difference in main effects. Multiple Classification Analysis (MCA) was considered to determine the specific contribution of the levels of advance organizers to the gain in student's achievement in chemistry.

Table 2 shows a multiple regression index of $R = 0.79$ with a multiple regression squared index of $R^2 = 0.63$. This implies that 63% of the total variance in the achievement of students in chemistry is attributable to the influence of advance organizers.

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Table 1: One-way analysis of covariance (ANCOVA) of post-test scores of students taught with pictorial organizer, written organizer and those not taught with advance organizer using pre-test scores as covariates

Source of variation	SS	DF	MS	F	Decision at $P < .05$
Pretest	104.27	1	104.27	7.26	*
Main effects	3114.73	2	1557.36	108.39	*
Explained	3219.00	3	1073.00	74.68	*
Residual	1925.38	134	14.37		
Total	5144.38	137	37.55		

* = significant at $P < .05$ level F-critical = 3.92

Table 2: Multiple Classification Analysis (MCA) of post-test scores of students taught with pictorial organizer, written organizer and those not taught with advance organizers

Variable + Category	N	Unadjusted for independent variable and covariates		Adjusted for independent variable and covariates	
		Deviation	Beta	Deviation	Beta
Advance organizers			0.79		0.78
Pictorial organizer	44	4.91		4.84	
Written organizer	46	1.97		2.00	
No organizer	48	-6.39		-6.35	
Multiple R-squared = 0.63					
Multiple R = 0.79					

Table 3: Results of Scheffe's post hoc test for multiple comparisons of advance organizers on students' achievement in chemistry

Dependent variable: Post-test							
(I) Advance organizer	(J) Advance organizer	Means difference	Std error	Sig.	95% confidence level		
				Lower bound			Upper bound
PO	WO	2.9368*	.801	.002	.9544	4.9191	
	WAO	11.2955*	.793	.000	9.3334	13.2575	
WO	PO	-2.9368*	.801	.002	-4.9191	.9544	
	WAO	8.3587*	.784	.000	6.4190	10.2983	
WAO	PO	-11.2955*	.801	.000	-13.2575	-9.3334	
	WO	-8.3587*	.784	.000	-10.2983	-6.4190	

*the mean difference is significant at 0.05 level

Key: PO = Pictorial Organizer WO = Written organizer WAO = Without Advance Organizer

organizers and direction of significance under investigation, the post-test scores were subjected to Scheffe multiple comparison test for a post hoc analysis as shown in Table 3.

As shown in Table 3, the mean difference between PO and WO was 2.94, between PO and WAO was 11.30 and between WO and WAO was 8.36. This implies that pictorial organizer was the most effective in facilitating students' achievement in chemistry. This was then followed by written organizer while the non-advance organizer was found to be least effective in facilitating students' achievement in chemistry.

Hypothesis Two (H_02): There is no significant difference in the retention ability of chemistry students taught with pictorial organizer, written organizer and those taught without advance organizer.

Table 4 shows that the retention ability main effect was significant at $P < .05$. The calculated F-value 385.28 was greater than the F-critical of 3.92; therefore the null hypothesis H_02 was rejected. Multiple Classification Analysis contribution of the levels of advance organizers to the ability to retain materials taught.

Table 4: One-way analysis of covariance (ANCOVA) of retention score of students taught with pictorial organizer, written organizer, and those taught without advance organizer using pre-test scores as covariates

Source of variation	SS	DF	MS	F	Decision at $P < .05$
Pre-test	186.17	1	186.17	30.57	*
Main effects	4692.69	2	2346.35	385.28	*
Explained	4878.86	3	1626.29	267.05	*
Residual	816.05	134	6.09		
Total	5694.91	137	41.57		

*=significant at $P < .05$ level F-critical = 3.92

Table 5 showed a multiple regression index $R = 0.93$ with a multiple regression squared index of $R^2 = 0.86$

This implies that 86% of the total variance in the retention of materials taught to chemistry students is attributable to the influence of advance organizers. However, to determine the order of effectiveness of advance organizer and direction of significance under investigation, the retention scores were subjected to Scheffe multiple comparison test for a post hoc analysis as shown in Table 6.

As shown in Table 6, the mean difference between the PO and WO was 1.68 between PO and

Table 5: MCA of retention scores of students taught with pictorial organizer, written organizer and those not taught with advance organizers

Variable + Category	N	Unadjusted for independent variable and covariates	Beta	Adjusted for independent variable and covariates	Beta
Advance organizers			0.92		0.91
Pictorial organizer	44	5.14		5.02	
Written organizer	46	3.47		3.51	
No organizer	48	-8.804		-7.97	

Multiple R-squared =0.86 Multiple R = 0.93

WAO was 13.18 and between WO and PO was 11.51. This implies that pictorial organizer was the most effective in facilitating students’ retention in chemistry. This was then followed by written organizer while the non-advance organizer was seen to be least effective in facilitating students’ retention in chemistry.

Hypothesis 3(i) [$H_0 3(i)$]: there is no significant difference between the achievement of male and female chemistry students taught with pictorial organizer.

The analysis in Table 7 showed that the calculated t-value, 0.30 is less than the critical t-value, 2.01 at $P < .05$. Therefore, the null hypothesis $H_0 3(i)$ was accepted.

Ho3 (ii): There is no significant difference between the achievement of male and female chemistry students taught with written organizer.

DISCUSSION

The findings of this study showed that a significant difference was found to exist among the achievement of chemistry students taught with pictorial organizer, written organizer and those not taught with advance organizer. The post hoc analysis also showed that pictorial organizer was

found to be most facilitating, followed by written organizer and non-advance organizer was the least in enhancing students’ achievement in chemistry. This might have been due to the stability and clarity of anchoring ideas that the organizer provided in the cognitive structure of the experimental group of the chemistry students. This study corroborated the findings of (Kang 1996; Mayer 2003; Shihusa and Keraro 2009) that advance organizers enhance students’ performance and facilitate meaningful learning.

The findings in this study showed that there was a significant difference among students taught with pictorial organizer, written organizer and those not taught with advance organizer with respect to their ability to retain materials taught. The post hoc analysis also indicated that pictorial organizer was found to be most facilitating followed by written organizer and non-advance organizer was the least in enhancing students’ retention in chemistry. This might be due to the fact that advance organizer seemed to make students remember more conceptual ideas and were able to relate the test to prior knowledge. This was consistent with the findings of (Mayer and Bromage 1980; Mayer 2002; Demide 2010) that advance organizers facilitated

Table 6: Results of Scheffe’s post hoc test for multiple comparisons of advance organizers on student’s retention ability in chemistry

Dependent variable: Retention scores						
(I) Advance organizer	(J) Advance organizer	Mean difference (I-J)	Std error	Sig.	Lower bound	Upper bound
PO	WO	1.6790*	.538	.009	.3434	2.9995
	WAO	13.1818*	.531	.000	11.8669	14.4968
WO	PO	-1.6709*	.538	.009	-2.995	.3434
	WAO	11.5109*	.525	.000	10.2109	12.8108
WAO	PO	-13.1818*	.531	.000	-14.4968	-11.8669
	WO	-11.5109*	.525	.000	-12.8108	-10.2109

*the mean difference is significant at 0.05 level

Key: PO = Pictorial organizer WO = Written organizer WAO = without advance organizer

Table 7: t-test comparison of post-test mean score on achievement of male and female chemistry students taught with pictorial organizer

Gender	N	SD	DF	t-calculated	t-critical	Decision at P < .05	
Male	20	40.95	2.37	42	0.30	2.01	NS
Female	20	40.71	2.87				

NS = Not significant

meaningful learning and retention of chemistry concepts.

The findings of this study also showed that there was no significant difference between the achievements of male and female chemistry students taught with pictorial and written organizers. The non-significant difference in the achievement of male and female chemistry students agreed with the findings of Nsofor (2001) who reported that both male and female could do well in science if exposed to similar learning conditions. However, Dawson (2000), and Prokop et al. (2007) found significant gender difference in biology.

CONCLUSION

From the findings of the study, it could be concluded that pictorial organizer is more effective in enhancing students' achievement and retention in chemistry than written organizers. Also, chemistry students taught with advance organizers performed better than those not taught with advance organizers. Finally, no significant difference was observed between the achievement of male and female chemistry students taught with pictorial and written organizers.

RECOMMENDATIONS

From the conclusion, it was recommended that:

1. Chemistry teachers should adopt the use of pictorial organizers in teaching the concept of heat change.
2. Textbook authors should adopt the advance organizer strategy in presenting materials in their books.
3. Seminars/workshops should be organized for chemistry teachers to appraise them with the use of advance organizers.

NOTE

1. SS2 Means SENIOR SECONDARY 2 (in Nigeria, a child spends six (6) years in the Secondary School. The First Three (3) years is called Junior Second-

ary 1 to 3 and the last three (3) years is called Senior Secondary 1 to 3 i.e. JS 1-3 and SS1-3).

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