COMPERATIVE EFFECTIVENESS OF ANALOGY AND CONCEPT MAPS INSTRUCTIONAL STRATEGIES ON SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY IN ANAMBRA STATE

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Abstract
This research was an effort to determine the relative effectiveness of analogy and concept maps instructional strategies on senior secondary two (SS2) students academic achievement in chemistry in Njikoka/Dunukofia Local Government Area (LGA) of Anambra State. The study was guided by three research questions and three null hypothesis tested at 0.05 alpha level. The study adopted a non equivalent pretest posttest control group quasi-experimental design involving two treatment groups. The sample comprised 55 SS2 students that offer chemistry who were drawn from two co-educational schools out of the 11 co-educational secondary schools using two-stage sampling procedure. The instrument for data collection was Chemistry Achievement Test (CAT). The CAT was validated by three experts and two secondary school chemistry teachers. The reliability coefficient of 0.79 was obtained using Kuder-Richardson formula (K-R 20). The CAT was administered as pretest for both experimental groups followed by a posttest after treatment was given using analogy and concept maps lesson plans. For data analysis, the pretest and posttest scores of the chemistry students were used. Analysis of the data using the Mean, S.D and ANCOVA showed among others that there was no significant difference between the mean achievement scores of chemistry students taught using analogy instructional strategy when compared with those taught with concept maps instructional strategy. This means that none of the strategies was superior to the other. The result of the study equally showed no significant difference between the mean achievement scores of male students when compared with that of their female counterparts for both strategies. Consequently, it was recommended that since both strategies showed no significant difference in their effectiveness on students' academic achievement in chemistry, teachers should adopt the use of both strategies in teaching of chemistry for enhanced achievement in the subject.

INTRODUCTION

The global concern for the advancement in science and technology necessitates the need to improve the quality of science education in Nigeria. Undoubtedly, excellence in academic achievement demands high level of intelligence. Research has shown that the extent to which students utilize their cognitive abilities is important and may contribute to better academic achievement. The cognitive abilities of students refer to the way the students perceive, pay attention, remember, think and understand the concept being presented to them. It is used by the students in receiving information, comprehending it, retrieving it and using it to make decisions and solve problems (Dzulkifli & Alias, 2012).

In respect of the above facts, analogies are believed to help students' learning by visualization of abstract concepts and by helping to compare similarities of the students' motivation (Dilber &Duzgun 2008). Simply stated, analogy is a process of identifying similarities between two concepts; one is the "target concept" which is the actual topic to be taught to the students and another is the "analog concept" created by the teacher which is used as a basis for structural comparison. The analog concept enables him to explain the target concept to the students explicitly by comparing the similarities between the two concepts. This is because the analog concept is more familiar to the students than the target concept which has abstract nature. Analogy as an instructional strategy is now often considered by educators and researchers as a strategy to provide creative solutions (Paris & Glynn in Serkan, 2011). In terms of problem in the field of chemistry, Gongden (2016) recommended the use of analogies as strategies for teaching problem tasks in electrolysis to male students. According to Yildirim et al. (2013), it was emphasized that teachers need to employ strategies that help students concretize the events taking place in chemical equilibrium at three levels in the instructional process. One of these strategies is analogy.

In a continued effort by the teachers and those in educational sector to improve students' achievement in chemistry, it has been noted that the ability to apply knowledge requires a stable conceptual framework. One effective way of establishing a framework is to create "Concept Maps". Concept maps are diagrams in which various forms or lists of information are classified and their links are shown (Xiaojie, 2004). As Xiaojie emphasized, concept mapping strategy can serve as a key to teach a topic. According to Brinkerhoff and Booth (2013), concept maps are always used in conjunction with other teaching strategies.

Research studies, example Barbara, Sasa and Janez (2015), which relates to concept mapping, indicated that concept mapping had positive effects both on students' achievements as well as on their attitude. According to Remero, Cazorla and Buzon (2017), the use of concept maps provides series of advantages to students among which is promoting agility and skill in organizing concepts in a specific subject area

and they stated that empirical evidence exists which support that the introduction of concept maps promotes significant learning. Concept maps as a teaching strategy, is parallel with the movement from teacher to learner-centered method which has power to improve academic achievement (Sakiyo& Waziri, 2015). They reported that students taught using concept mapping strategy performed better than those taught using inquiry and lecture methods. Concept maps instructional strategy is an effective method of presenting science concept to the students to achieve meaningful learning (Udeani& Okafor, 2012).

Chemistry as a science subject is full of abstract and challenging concepts that are not easy to understand unless they are related to something from our everyday experiences. Students have continued to achieve poorly in chemistry in spite of provisions made by Federal and State Governments of Nigeria for effective teaching and learning of chemistry in schools. For instance, many researchers (Omoreogbe& Ewansiha, 2015; Gambari et al, 2016; Adenipekun, 2018) reported a decline in the performance level in SSCE Chemistry, a situation which is worrisome to the stake holders in the educational sector. Furthermore, use of adequate instructional strategies that would be able to relate most of the predominant abstract and challenging concepts in chemistry to something from students' everyday experiences is lacking. The usual rote learning that are passive still appears to dominate the more activity -based learning. Moreover, factors such as gender and inappropriate instructional strategies had been identified as affecting students' achievement in chemistry.

Historically, many studies bothering on academic achievement cannot be unconnected with gender. In many countries of the world, the educational provision for boys and girls was clearly differentiated (Sani, 2011). Explaining further, Sani added that this gender gap can equally be observed in science disciplines such as chemistry and physics. According to Gongden (2016), in his study, the result showed that male chemistry students benefited more in problem solving task involving electrolysis than female students when taught with analogy. However, Chawla (2013) discovered that male and female students in his experimental study did not differ in their achievements in chemistry. Therefore, as part of effort to meet the objectives of Nigerian Secondary School Chemistry Curriculum and improve the cognitive abilities of chemistry students, the researchers conceived the present investigation.

Statement of Problem

The abstract nature of chemistry concepts makes the subject difficult for students to understand resulting in poor academic achievements in schools. In a bid to ameliorate the poor academic achievement and increase the standard of education due to a decline in the performance level in SSCE chemistry, many researchers had identified analogy and concept maps as effective instructional strategies. Some

studies had also compared the effectiveness of analogy with other instructional strategies while others compared the effectiveness of concept maps with other strategies but no study had compared the effectiveness of analogy and concept maps instructional strategy in teaching chemistry. Also there was the need to identify whether gender was a factor in the way students respond to analogy and concept maps. It is against this background that the researchers investigated the relative effectiveness of analogy and concept maps instructional strategies on secondary school students' academic achievement in chemistry.

Purpose of the Study

The aim of this study was to determine the comparative effectiveness of analogy and concept maps instructional strategies on secondary school students' academic achievement in Chemistry in Njikoka/Dunukofia Local Government Area (LGA) of Anambra State. Specifically, the study aimed at determining the following:

1. The pretest and posttest mean achievement scores of students taught chemistry using analogy instructional strategy (AIS) and those taught chemistry using concept maps instructional strategies (CMIS).
2. The pretest and posttest mean achievement scores of male and female students taught chemistry using analogy instructional strategy (AIS).
3. The pretest and posttest mean achievement scores of male and female students taught chemistry using concept maps instructional strategy (CMIS).

Scope of the Study

The study considered only senior secondary two (SS2) students in Njikoka/Dunukofia LGA of Anambra State and was limited to the concept of "Rate of chemical Reaction". The study concentrated on the sub-topics: Reaction rate, calculations involving reaction rates, factors affecting rate of chemical reaction, collision theory as well as Exothermic and Endothermic reactions.

Research Questions

1. What are the pretest and posttest mean achievement scores of students taught chemistry using analogy instructional strategy (AIS) and those taught using concept maps instructional strategy (CMIS)?
2. What are the pretest and posttest mean achievement scores of male and female students taught chemistry using analogy instructional strategy (AIS)?
3. What are the pretest and posttest mean achievement scores of male and female students taught chemistry using concept maps instructional strategy (CMIS)?

Hypotheses

1. There is no significant difference between the pretest and posttest mean achievement scores of students taught chemistry using analogy instructional strategy and those taught using concept maps instructional strategy

2. There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using AIS
3. There is no significant difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using CMIS

Methodology

This study adopted a quasi-experimental design. Specifically, a non- equivalent pretest posttest experimental group design was used. The study involved the use of two treatment groups. The design represented two levels of treatment "Analogy Instructional Strategy" and "Concept Maps Instructional Strategy"

E_1	O_1	X_1	O_2
E_2	O_1	X_2	O_2

Figure 1: Design of the Experiment

Where:

O_1= Pretest for E_1 and E_2

O_2= Posttest for E_1 and E_2

X_1 and X_2= Analogy and concept maps (treatments) given to groups E_1 and E_2.

The study was carried out in the selected secondary schools within Njikoka and Dunukofia Local Government Areas (LGAs) in Awka Education Zone of Anambra State, Nigeria. The study was conducted in these LGAs because it would help to improve the academic achievement of a good number of students at the end of the study. This study used SS2 students and the reason for this choice was because they had attained the required cognitive level to cope with the teaching strategies that were applied in the study. Equally this class of students was in the preparatory stage for senior school certificate examination (SSCE). The population comprised 483 SS2 students in the 19 senior secondary schools in Njikoka and Dunukofia LGAs of Awka Education Zone. Out of these 19 schools, 11 schools were co-educational comprising 263 SS2 chemistry students (159 male and 104 female). The sample size was 55 Chemistry students, comprising 32 male and 23 female students drawn from the two senior secondary schools selected out of the 11 co-educational schools in Njikoka and Dunukofia LGAs. The sampling was done using a two-stage sampling procedure (purposive and simple random sampling techniques). According to Nworgu (2015), the purposive sampling is relevant when specific elements which satisfy some predetermined criteria, based on researcher's judgment, are to be selected. The schools were purposively sampled because: (1) they recorded poor achievements in chemistry for the past years. (2) They were co-educational schools. In the second stage, simple random sampling was applied to assign the two schools to the two experimental groups.

The instrument that was used in this study for data collection was the Chemistry Achievement Test (CAT). The CAT consists of 30 multiple choice test items that were selected from past examination questions of West African Examination Council (WAEC) and National Examination Council (NECO). The CAT captured two major concepts: Rate of a chemical reaction covering rapid/slow reactions, its calculations, ways of measuring reaction rates as well as variation in rates and collision theory covering exothermic/endothermic reactions, activation energy, effective collision as well as factors affecting reaction rates. The CAT measured the key areas in the contents using a table of specification. The instrument was validated by three science educators and two experienced secondary school chemistry teachers. The reliability coefficient of 0.79 was obtained using Kuder Richardson formula (K-R20).

For the pretest, CAT on rate of chemical reaction was administered to the two experimental groups in the two sampled schools before treatment. The test was administered by the two trained chemistry teachers and their two assistants at the appropriate time allotted for the test. During the treatment using the analogy lesson plan, acid reaction with marble chip was represented in different concentrations as 2.0M acid, 1.5M, 1.0M and 0.5M of acid to differentiate their strength which in turn determines their rates of reaction. These acid concentrations were analogous to what was explained using athletes on track racing A, B, C and D (100 or 200 meters, 800 or 1500 meters, 8000 meters and marathon racing) for better understanding by the students.

For concept maps, students were introduced to the following general approach; Contextualization, Brainstorming phase and Layout phase to construct concept maps in relation to the chosen topic. In the final step, specific examples were given below concepts to solidify meaning. Students were told to make a concept map into a well-organized permanent form for their consumption. It should be of note that concepts maps are never finished but depend on the area you want your lesson to be buttressed more. In one of the tasks given to the students, a photocatalytic reaction between hydrogen and chlorine when carried out in a dimly lit room was presented by the following equation.

$$H2_{(g)} + Cl2_{(g)} \longrightarrow 2Hcl_{(g)} \; ; \; \Delta H = - x \; Kjmol^{-1}$$

Question:

Looking at this equation in the concept maps before you;

1. Identify the reactants and the product
2. Is the reaction an endothermic or an exothermic reaction?
3. List three other examples of reactions that can be affected by presence of light (photo catalytic reaction).

During the data collection, the pretest was only used to determine the students' initial group equivalence but posttest for the two treatment groups was

marked and the scores recorded accordingly. The data collected from the two groups were used for analysis based on the intended objectives of the research questions and hypotheses. The research questions were answered using mean and standard deviation while the hypotheses were tested with Analysis of Covariance (ANCOVA), at 0.05 alpha levels. This was because ANCOVA enabled the researchers to handle the error due to problem of non-equivalent groups.

Results

Table 1:The pretest and posttest mean achievement scores of students taught chemistry in the two treatment groups.

Instructional Strategy		**Pretest**		**Posttest**		
	N	Mean	SD	Mean	SD	Mean Gain
Analogy	25	25.96	7.75	61.64	10.19	35.68
Concept Maps	30	26.23	7.43	60.90	8.58	34.67

The result in Table 1 showed the means and standard deviations in the pretest and posttest for both AIS and CMIS. The mean gain score of students taught chemistry using AIS was 35.68 which was slightly higher than that of CMIS (34.67).This means that Analogy group achieved slightly higher than concept maps group.

Table 2: The pretest and posttest mean achievement scores of male and female students taught chemistry using Analogy Instructional Strategy (AIS).

Instructional Strategy			**Pretest**		**Posttest**		
	Gender	N	Mean	SD	Mean	SD	Mean Gain
Analogy	Male	15	25.80	7.31	63.20	11.24	37.40
	Female	10	27.20	7.59	59.30	8.39	32.10

Table 2 presented the means and standard deviations in the pretest and posttest for both male and female in AIS group. The male students had a higher mean gain score of 37.40 as against 32.10 of the female students. This means that male students taught using analogy achieved better than their female counterparts. Therefore, AIS enhanced male students' achievement in chemistry more than their female counterparts.

TABLE 3: The pretest and posttest mean achievement scores of male and female chemistry students taught chemistry using Concept Maps Instructional Strategy (CMIS).

Instructional Strategy		Pretest			Posttest		
	Gender	N	Mean	SD	Mean	SD	Mean Gain
	Male	17	25.06	7.81	60.24	8.79	35.18
Concept Maps	Female	13	27.77	7.43	61.77	8.56	34.00

Table 3showed the means and standard deviations in the pretest and posttest for both male and female students in CMIS group. The male students had a higher mean gain score of 35.18 as against 34.00 of the female students. This means that male students taught using CMIS achieved better than their female counterparts. Therefore, CMIS enhanced male students' achievement in chemistry more than their female counterparts.

Table 4:ANCOVA test of significant difference between mean achievement scores of students in the two groups.

Source	Type III Sum of Squares	Df	Mean Square	F.cal	Sig.
Corrected model	3410.471[a]	4	852.618	34.845	.000
Intercept	4538.642	1	4538.642	185.484	.000
Pretest	3294.410	1	3294.410	134.635	.000
Method	6.157	1	6.157	.252	.618
Gender	103.794	1	103.794	4.242	.045
Method Gender	29.737	1	29.737	1.215	.276
Error	1223.456	50	24.469		
Total	10878.000	55			
Corrected Total	8500.747	54			

a. R squared = .736 (Adjusted R squared = .715)

An examination of data from Table 4 showed that F(1,50) =0.252, P = 0.618. Since P= 0.618 was greater than 0.05 level of significance, the difference in mean was not significant. As a result, the null hypothesis of no significant difference was accepted. Therefore, the study upheld that there is no significant difference between the mean achievement scores of students taught chemistry using AIS and those taught using CMIS.

Table 5:ANCOVA test of comparison of mean achievement scores of male and female students taught using AIS.

Source	Type III Sum of Squares	Df	Mean Square	F.cal	Sig.
Corrected model	1174.591[a]	2	887.296	27.143	.000
Intercept	2153.907	1	2153.907	65.495	.000
Pretest	1683.331	1	1683.331	51.495	.000
Gender	112.532	1	112.532	3.442	.077
Error	719.169	22	32.689		
Total	97491.000	25			
Corrected Total	12493.760	24			

a. R squared = .712 (Adjusted R squared = .685)

An examination of data from Table 5 showed that F(1,22) = 3.442, P = 0.077 for effect of gender. Since P= 0.077 was greater than 0.05 level of significance, the difference in mean was not significant. As a result, the null hypothesis of no significant difference was accepted. Therefore, the study upheld that there is no significant difference between the mean achievement scores of male and female students of chemistry when taught using AIS.

Table 6:ANCOVA test of comparison of mean achievement scores of male and female students taught using CMIS.

Source	Type III Sum of Squares	Df	Mean Square	F.cal	Sig.
Corrected model	1630.970[a]	2	815.485	27.785	.000
Intercept	2382.705	1	2382.705	130.262	.000
Pretest	1613.636	1	1613.636	94.147	.000
Gender	10.870	1	10.870	.620	.451
Error	501.730	27			
Total	113397.000	30			
Corrected Total	2132.700	29			

a. R squared = .765 (Adjusted R squared = .747)

An examination of data from Table 6 above showed that F(1,27) = 0.620, P= 0.451 for the effect of gender. Since P = 0.451 was greater than 0.05 level of significance, the difference in mean was not significant. As a result the null hypothesis of no significant difference was accepted. Therefore, the study upheld that there is no significant difference between the mean achievement scores of male and female students of chemistry when taught using CMIS.

Discussion

The findings of the study showed that analogy is an effective instructional strategy as well as concept maps. The reason is because the mean achievement scores of AIS and CMIS showed no significant difference when compared. This means that both strategies were of equal effectiveness when teaching chemistry students. The above finding was supported by the finding from the study done by Yildrim et al. (2013), who found that analogy based instruction showed a significant difference when compare with the traditional method.

On the other hand, concept maps had proven to be effective since those in Analogy instructional strategy did not achieve higher than concept maps instructional strategy. The finding was in agreement with that of Udeani and Okafor (2012) who found out that the group taught using concept mapping instructional strategy performed significantly better than their expository group counterpart. Therefore, Concept map is an effective instructional strategy. It is of note that no study had compared the relative effectiveness of Analogy and Concept maps instructional strategies. Therefore, the study has shown that between Analogy and Concept maps, no strategy is better than the other in effectiveness. Both strategies are effective in teaching chemistry.

The findings of the study equally revealed that male students taught using analogy instructional strategy did not achieve significant higher than female counterpart. This reason is because the mean achievement scores of male and female students did not differ significantly. Therefore, gender should not be a factor when using analogy to teach chemistry students because neither male nor female achieved significantly better than the other. The finding agreed with that of Samara (2016), who discovered that there was no statistically significant difference in the achievement of male and female students taught using analogies. However, the finding disagreed with the study by Gongden (2016), who revealed that male students performed better than the female students in a chemistry problem solving test involving electrolysis when taught using analogy.

Furthermore, the findings of this study equally revealed that male students did not achieve significantly higher than their female counterparts when taught using concept maps. The reason is because the mean achievement scores of male and female students did not differ significantly. Therefore, gender should not be a factor when using concept maps instructional strategy to teach chemistry students because neither male nor female students achieved significantly better than the other. The finding was supported by that of Sakiyo and Waziri (2015) who revealed that there was no gender difference in students' academic achievement in Biology when taught using concept mapping. Study by Chawla (2013) equally showed that male and female students taught using concept mapping did not differ significantly in their achievement in chemistry.

Conclusion

This study had shown that both analogy and concept maps instructional strategies had significant effect on students' academic achievement in chemistry. On the other hand, the relative effectiveness of Analogy and Concept maps instructional strategies, when compared, had no significant difference on students' academic achievement in chemistry. It was also concluded that gender had no effect on academic achievement of chemistry students when Analogy and Concept map instructional strategies were used in teaching chemistry.

Recommendations

The following recommendations were made from the outcome of this study:

1. Since the use of Analogy and Concept map had enhanced students' achievement in chemistry, chemistry teachers should be encouraged to adopt them often in the classroom. In so doing, the cognitive ability of those students who do not perform well would be improved significantly.
2. Teachers should be using examples and illustrations that employ students' previous experience in explaining concepts being taught.
3. Learning should incorporate whole concepts, not isolated parts, so that students could see the links among concepts they have learnt, the ones they are learning and those they ought to learn. This would motivate them to learn efficiently.

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