



## Relative Effectiveness of Analogy and Concept Maps Instructional Strategies on Secondary School Students' Academic Achievement in Chemistry.

**Obi, Okenwa Kennedy<sup>1</sup> & Okigbo, Ebele Chinelo<sup>2</sup>**

<sup>1</sup>Nwafor Orizu College Demonstration Secondary School, Awka.

<sup>2</sup>Department of Science Education Nnamdi Azikiwe University, Awka.

**Corresponding Author:** [ken1978.obi@gmail.com](mailto:ken1978.obi@gmail.com)

### Abstract

This research determined the relative effectiveness of analogy and concept maps instructional strategies on senior secondary two (SS2) students' academic achievement in chemistry in Njikoka/Dunukofia LGA of Anambra State. 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. The instrument for data collection was chemistry Achievement Test (CAT). The reliability coefficient of 0.79 was obtained using Kuder-Richardson formula (K-R 20). Analysis of the result using the Mean, S.D and ANCOVA showed no significant difference on students' academic achievement when taught using analogy instructional strategy compared with concept maps instructional strategy. Moreover, the result equally showed a significant difference on the academic achievement of male students when compared with their female counterparts. Consequently, it was recommended that chemistry teachers should adopt the both strategies in teaching chemistry.

**Keywords:** Analogy, Concept Maps Instructional Strategies, Academic Achievement in Chemistry.

### Introduction

The global concern for the advancement in science and technology necessitates the need to improve the quality of science education in Nigeria. Science education, according to Omorogbe and Ewansiha (2013), is a field of study concerned with producing a scientifically literate society. They asserted that science education acquaints students with certain basic knowledge, skills and attitude needed for future work in science and science related fields. Therefore, Ajaja (2013) maintained that the major concern of science education researchers is the identification of the best instructional methods/strategies which will enable all learners to learn effectively.

In respect of the above facts, analogies are believed to help students' learning by visualization of abstract concepts, 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



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), related to concept mapping indicate that concept mapping has 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 supports that the introduction of concept maps promotes significant learning.

It is worthy of note that analogy and concept maps are instructional strategies that are built on the theory of constructivism. According to Akpan and Beard (2016), constructivists teaching philosophy is all about accepting student's autonomy where student's thinking drives the lessons, where dialogue, inquiry and puzzlement are valued and assessing student's learning is in the context of teaching. Continuing, Akpan and Beard stated that constructivist's instructions are practical in nature; focus on real-life applications that might be used to refocus

the process of educational reform. As noted by Olajide and Adeoye (2010), brain is an analogy processor, that is, it works by analogy and metaphors and relates whole concept to another and looks for similarities, differences and relationships between them. Therefore, analogy provides similarities which makes learning easier for students by reflecting on their experiences while concept maps brings the whole abstract concept to a concise manner for chemistry students. Equally, many researchers, Paris and Glynn in Serken, 2011; Udeani and Okafor, 2012; Singh and Moono, 2015; Sakiyo and Waziri, 2015; Romero, Cazorla and Buzon, 2017, had identified analogy and concept maps as effective instructional strategies.

Chemistry as a subject is full of abstract and challenging concepts that are not easy to understand unless they are related to something from our everyday experiences. Some of the abstract and challenging concepts are Electrolysis, Chemical Equilibrium, Rates of Chemical Reactions, Redox Reactions and Electrochemistry. These concepts are embedded majorly in a branch of Chemistry called Physical Chemistry. Specifically, the study was limited to the concept of "Rates of Chemical Reactions". The study concentrated on the sub-topics: Reaction rates, Calculations involving reaction rates. Factors affecting rate of chemical reaction, collision theory, Exothermic and Endothermic reactions. Due to the many chemical Laws, theories, calculations and illustrations involved in this aspect of chemistry, students find it difficult to comprehend easily. Moreover, questions from this area of chemistry appear more often in external examinations such as WAEC, NECO and JAMB. As a result, 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. This difference in treatment through education created gender gap (Sani, 2011). Explaining further, Sani added that this gender gap can equally be observed in science disciplines such as chemistry and physics. Therefore, as part of the 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, as outlined above, 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 order to find out which strategy is more effective in teaching chemistry. Also, there was the need to identify whether gender was a factor to 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.

Based on the problem of the study, the researchers determined the relative effectiveness of analogy and concept maps instructional strategies on secondary school students' academic achievement in Chemistry. Specifically, the study aimed at determining the following:

1. The mean achievement scores of students taught chemistry using analogy instructional strategy (AIS) and those taught chemistry using concept maps instructional strategies (CMIS).
2. Influence of gender on students' academic achievement in chemistry.

### Scope of the Study

The study considered only senior secondary school two (SS2) students in Njikoka/Dunukofia LGA of Anambra State which were predominately remote schools in order to find out which of these two effective strategies could enhance students'

academic achievement better than the other. The study was limited to the concept of “Rate of chemical Reaction” and treated the following sub-topics: Reaction rates, calculations involving reaction rates, factors affecting rate of chemical reaction, collision theory as well as Exothermic and Endothermic reactions. The reason for choosing these concepts was due to the many chemical Laws, theories, calculations and illustrations involved in this aspect of chemistry making it difficult for students to comprehend easily. Moreover, questions from this area of chemistry appear more often in external examinations such as WAEC, NECO and JAMB.

Based on the purpose of the study, the following research questions were posed to guide the study.

1. What are the 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 mean achievement scores of male and female students taught chemistry?

The following null hypotheses were formulated to guide the researcher in the study.

1. There is no significant difference between the 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 mean achievement scores of male and female students taught chemistry.

## Method

This study adopted a quasi-experimental design involving the use of two treatment groups (Analogy Instructional Strategy and Concept Maps Instructional Strategy).

E <sub>1</sub>	O <sub>1</sub>	X <sub>1</sub>	O <sub>2</sub>
E <sub>2</sub>	O <sub>1</sub>	X <sub>2</sub>	O <sub>2</sub>

**Figure 1:** Design of the Experiment

Where:

O<sub>1</sub>= Pretest for E<sub>1</sub> and E<sub>2</sub>

O<sub>2</sub>= Posttest for E<sub>1</sub> and E<sub>2</sub>

X<sub>1</sub> and X<sub>2</sub>= Analogy and concept maps (treatments) given to groups E<sub>1</sub> and E<sub>2</sub>.

The study was carried out in the selected secondary schools within Njikoka and Dunukofia Local Government Areas (LGAs) within 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 considered SS2 and the reason for this choice was because they had attained the required cognitive level to cope with the contents of the lesson plans that were used 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. This data was obtained from the Post Primary Service Commission (PPSC). 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 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 were located in remote areas where these instructional strategies would largely improve their cognitive level. (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: Rates 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 test items were based on syllabus and scheme of work. 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). It was used because the test was dichotomously scored. Moreover, the items had varying difficulties with each item having one correct answer.

Adequate measures were taken to control the extraneous variables that might

affect the study such as: Experimenter bias, Teachers variability, Instructional variability, Effect of pretest and posttest and Subjects' interaction. In order to control experimenter bias, the researcher trained the regular chemistry teachers so that regular students were used for the experiment instead of inviting external students. Teacher's variability was controlled using some well-structured lesson plans to guide the teachers. Instructional variability was controlled by directing the teachers to adhere strictly to the lesson plans and ensure that they were taught within the same time bound. Effect of pretest and posttest was controlled through reshuffling of the test items resulting in the posttest having different numbering with the pretest. Finally, subjects' interaction was controlled by ensuring that the students were from different schools far apart from one another.

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

Research Question 1: What are the mean achievement scores of students taught chemistry using analogy instructional strategy (AIS) and those taught using concept maps instructional strategy (CMIS)?

**Table 1:** This table shows the mean achievement scores of students taught chemistry using AIS and CMIS.

Instructional Strategy	N	Pretest		Posttest		$\bar{x}$ Gain
		$\bar{x}$	SD	$\bar{x}$	SD	
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 25.68 which was slightly higher than that of CMIS (34.67). This means that Analogy group achieved slightly higher than concept maps group.

Research Question 2: What are the mean achievement scores of male and female students taught chemistry?

**Table 2:** This table shows the mean achievement scores of male and female students taught chemistry.

Gender	N	Pretest		Posttest		$\bar{x}$ Gain
		$\bar{x}$	SD	$\bar{x}$	SD	
Male	32	25.41	7.77	61.63	9.96	36.22
Female	23	27.09	7.19	60.70	8.39	33.61

Table 2 presented the means and standard deviations in the pretest and posttest for male and female in chemistry. The male students had a higher mean gain score of 36.22 as against 33.61 of the female students. Therefore, male students achieved higher than their female counterparts in chemistry.

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

**Table 3: ANCOVA test of significant difference between mean achievement scores of students taught chemistry using AIS and CMIS.**

Source	Type III Sum of Squares	Df	Mean Square	F.cal	Sig.
Corrected model	3410.471 <sup>a</sup>	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 3 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.

Hypothesis 2: There is no significant difference between the mean achievement scores of male and female students taught chemistry.

#### **ANCOVA test of significant difference between the mean achievement scores of male and female students taught chemistry.**

An examination of data in table 3 showed that  $F(1,50) = 4.242$ ,  $P = 0.045$ . Since  $P = 0.045$  was not greater than 0.05 level of significance, the difference in mean was significant. As a result, the null hypothesis of no significant difference was rejected. Therefore, the study upheld that there is a significant difference between the mean achievement scores of male and female students in chemistry.

#### **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. The above finding is supported by the study done by Olajide and Adeoye 2010 who found that "Analogical reasoning only group" showed a significant difference when compared with traditional method making it an effective instruction strategy.

On the other hand, Concept maps have 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 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 this study equally revealed that male students taught chemistry achieved significantly higher than female counterpart. The reason is because the mean achievement scores of male students was significantly higher than their female counterparts when compared. Therefore, gender should be a factor when using AIS and CMIS to teach chemistry students because male achieved significantly better than the female. The finding disagreed 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 agreed 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 finding disagreed with 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.

#### **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. Noting, also that gender had 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. Government should initiate programmes through which awards and rewards could be provided to students who excelled significantly in various subjects of interest to them. This would help to motivate them to learn.
3. Teachers should be using examples and illustrations that employ students' previous experience in explaining concept being taught.
4. 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.
5. School administrators as well as parents should see their students as

those who have the capacity to learn any concept and achieve greatly rather than see them as liabilities.

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