

EFFECTIVENESS OF CONCEPT MAPPING AS AN INSTRUCTIONAL STRATEGY FOR IMPROVING SECONDARY SCHOOL STUDENTS ACHIEVEMENT IN ACID, BASE AND SALTS IN TARABA STATE, NIGERIA

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Abstract

This study investigated the effectiveness of Concept mapping as an instructional strategy for improving secondary school students' achievement in acids, base and salts in Jalingo Education Zone of Taraba State, Nigeria. Quasi- experimental research design was used for the study. Sample of 150 Chemistry students from four intact classes were randomly selected from Government Secondary Schools in Jalingo Education Zone, Taraba State. Chemistry Achievement Test (CAT) with reliability index of 0.92 was used for data collection. Data collected were analyzed using mean, standard deviation, t-test and Analysis of Covariance (ANCOVA). Findings of the study revealed a significant difference in the mean achievement scores of students taught acids, base and salts in chemistry using Concept mapping and lecture method. Findings on gender however, revealed that there is no statistically significant difference in the mean achievement scores of male and female students taught acids, base and salts in chemistry using Concept mapping. Based on the findings, it is evident to conclude that the use of Concept mapping teaching strategy enhances achievement of students in chemistry than the lecture method of teaching. It is therefore recommended that pre-service and in-service teachers should be trained and encouraged to use Concept mapping teaching strategy since it gender friendly teaching strategy.

Keywords: Concept Mapping, Lecture Method, Gender, Acids, Base and Salts

Introduction

Teaching effectiveness is one of the most important factors determining the quality of education in any nation. A teacher's effectiveness depends on multiple interrelated factors, most especially on the pedagogical skill and instructional methods employed in the classroom in teaching chemistry. Chemistry is a fundamental science course that is essential for students who wish to pursue further studies in fields such as medicine, pharmacy, engineering, and computer engineering in tertiary institutions (Kayode, 2023). It therefore means that the teaching of chemistry in secondary schools is very crucial because it helps to equip students with the knowledge and skills needed to pursue further studies in the sciences and to develop a better assimilation of the world around them. Eze (2017) opined that chemistry can be defined as the scientific study of matter, its properties, the reasons why substances combine or separate to form other substances, and how they interact with energy. Bagley (2017) defines chemistry as the branch of science that deals with identifying substances that make up matter. To Omeje (2024), chemistry systematically studies the composition, properties and activities of both organic and inorganic substances and various elementary forms of matter. This discipline is crucial in the school science curriculum, especially for students considering careers in science.

Understanding chemistry is crucial because it helps us to comprehend the world around us and to appreciate the role that chemical processes play in shaping our daily experiences. By studying chemistry, students can acquire a deeper understanding of chemical reactions, chemical equilibrium, chemical thermodynamics, and chemical kinetics, among other essential topics. Effective teaching is so crucial to learning since it is product of teaching as knowledge, attitude and skill acquisition are much dependent on the teacher's effective teaching (Kayode,

2023). It is therefore imperative that chemistry teachers use instructional strategy that guarantees chemistry students understanding of chemistry concepts so that they can apply the knowledge to their everyday lives. Tochukwu and Ideba (2020) are of the view that Concept mapping is therefore, one of such teaching approaches that are interactive and that can arouse the engagements of students in learning chemistry.

Concept mapping teaching strategy is one of the innovative teaching strategies in the field of education. According to Samba and Eriba (2013) concept mappings is a process of constructing a graphical representation of knowledge of subject matter content for meaningful understanding of the concepts Chawla (2016) viewed concept mapping as somewhat similar to a spider chart, an organized chart of a flow diagram i.e. a concept map for teaching and learning is one, arranged in a hierarchical organization in which the more inclusive concepts at the top of the map and the more concrete and specific ones at the bottom. Concept mapping was first introduced by Novak in 1972 during his research work in Cornell University where he sought to understand changes in children's knowledge of science (Novak & Musonda, 1991). It holds that prior knowledge is used as a framework for understanding and learning new concepts. It is the process of creating a visual representation of one's knowledge (Kwantlen Polytechnic University, 2014). Concept mapping helps to strengthen the connecting contiguity among concepts and consequently ensure an improvement in performance and interest in a subject. Concept mapping approach provides a rich social environment for learners to work either individually or in collaboration to mediate meaning of concepts through linkages (Adah, 2019). Its activity-based and minds-on approach that guarantees students' participation, individual needs and differences, learning styles and ability unlike lecture method.

Lecture method is the traditional method, the expository method or the talk and chalk as well as conventional method of teaching which is the prevailing method of disseminating knowledge at virtually all levels of education in Nigeria (Jack & Gamnjoh, 2020). The lecture method, characterized by a teacher-centred approach where information is presented verbally to students, is one of the oldest and most widely used instructional strategies in education (Shuaibu et al, 2024). In chemistry education, the lecture method typically involves the teacher explaining chemical concepts, demonstrating problem-solving techniques, and providing examples, while students listen, take notes, and occasionally asks questions (Adebisi, 2020). This method is often favoured for its ability to cover a large amount of content within a limited time frame, making it particularly useful in settings with extensive curricula and time constraints. The lecture method has several advantages that can positively impact students' academic achievement in chemistry. Firstly, it allows for efficient coverage of the syllabus, ensuring that all necessary topics are taught within the academic year (Usman, 2021). This is particularly important in chemistry, where foundational concepts must be thoroughly covered to enable understanding of more complex topics. Additionally, lectures method provide a structured and organized presentation of material, which can help students follow the logical progression of chemical theories and principles (Brophy, 2019). Another benefit of the lecture method is that it offers opportunities for teachers to highlight key points and emphasize critical aspects of the subject matter. This can aid in focusing students' attention on important concepts and problem-solving strategies.

Despite its advantages, the lecture method also has several drawbacks that can negatively affect students' academic achievement in chemistry. One of the main criticisms is that it promotes passive learning. Students are often required to listen and take notes without actively engaging with the material, which can lead to superficial understanding and poor retention of knowledge (Adebisi, 2020). However, lecture method may not cater to the diverse learning needs and styles of all students. While some students may excel in a lecture-based

environment, others who benefit from more interactive and hands-on approaches may struggle to grasp chemical concepts (Olusola & Rotimi, 2022). This can create disparities in academic achievement, with some students falling behind due to the one-size-fits-all nature of traditional lectures. Furthermore, the lecture method can limit opportunities for critical thinking and problem-solving, which are essential skills in chemistry. Without active engagement and practice, students may find it challenging to apply theoretical knowledge to real-world problems, reducing their overall chemical proficiency (Akpan & Umoren, 2018). The lack of immediate feedback and interaction during lectures can also prevent students from addressing misunderstandings and misconceptions promptly.

Scholars such as Okereke and Ezechukwu (2016) which focused on the effectiveness of concept mapping on the academic performance of 136 senior secondary school students from two randomly selected schools in Anambra State, Nigeria. The study results indicated that the group that received concept mapping instruction performed significantly better than the control group in a chemistry achievement test. In a separate study by Ajewole and Ogunniyi (2018) using 100 senior secondary school students, with interest on the impact of concept mapping on secondary school students' achievement in chemistry in Ogun State, Nigeria. The study revealed that the experimental group that received concept mapping instruction had higher mean scores. Kayode (2023) in another study effectiveness of concept mapping in chemistry education among secondary school students found that students that were exposed to concept mapping strategy outperformed their counterpart that were exposed to conventional teaching method. Omeje (2024) also found that that there was a statistical significant difference in the mean achievement scores of the students taught chemistry concept of chemical bonding using concept mapping teaching strategy and those taught using lecture method.

However, Duarte et al., (2017) in their studies found that students can generally have low level of assimilation using the concept maps methods especially when proper guidance is not provided. Julius and Wachanga (2013); Ezeudu (2013) and Chawla (2015) revealed that concept mapping strategy eliminates gender disparity in achievement as they found in their separate studies that gender does not affect students' chemistry achievement when they are taught using concept mapping. In another related study, Agboola and Oloyede (2013) also earlier found that the gender of students has no effect on chemistry students' academic achievement when taught using concept mapping teaching strategy.

Purpose of the Study

The purpose of the study is to investigate the effectiveness of concept mapping as an instructional strategy for improving secondary school students' achievement in acid, base and salts. Specifically, the study aims to achieve the following:

1. To investigate whether there is any difference in the mean achievement scores of the group taught acids base and salts through concept mapping and those taught using lecture method in Jalingo Education Zone of Taraba State.
2. To investigate the difference in the mean achievement scores of male and female students taught acids, base and salts using concept mapping in Jalingo Education Zone of Taraba State

Research Questions

1. What is the difference in the mean achievement scores of the group taught acids base and salts through concept mapping and those taught using lecture method in Jalingo Education Zone of Taraba State?

2. What is the difference in the mean achievement scores of male and female students taught acids, base and salts using concept mapping in Jalingo Education Zone of Taraba State?.

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

H₀₁: There is no significant difference in the mean achievement scores of the group taught acids base and salts through concept mapping and those taught using lecture method in Jalingo Education Zone of Taraba State..

H₀₁: There is no significant difference in the mean achievement scores of male and female students taught acids, base and salts using concept mapping in Jalingo Education Zone of Taraba State.

Methodology

A pretest post-test control group quasi-experimental research design was adopted for the study. This design was considered appropriate because of its ability to identify cause and effect relationship due to treatment or intervention. According to Nworgu as cited in Danjuma (2015), this research design is used to establish cause and effect relationships between two or more variables. The design was chosen because it aimed at establishing the effect of learning strategies on students' achievement in acids, base and salts. This study consists of two instructional strategies (Concept Mapping and lecture method instructional strategies) which form the independent variables and students' academic achievement which is the dependent variable. The study involved an estimated population of all the 2646 students which offered chemistry in Jalingo Education Zone of Taraba State. There were two SSS II classes from two selected schools used as the Experimental Group (X1) while two other SSS II classes from other schools made up the Control Group (X2). All the four schools were selected to avoid communication between the students from different instructional treatments. The simple random sampling techniques was used for drawing samples from the four schools selected from the two Local Government Areas. 150 secondary school chemistry students formed the sample of the study through random sampling technique. These consisted of 90 male students and 60 female students.

The instrument was titled: Chemistry Achievement Test (CAT) and was subjected to face and content validity by three experts, two from Science Education and one from Measurement and evaluation respectively . The instrument was also pilot tested in one secondary school outside the Education Zone of Jalingo Education Zone. The scores obtained were subjected to reliability analysis using Kuder- Richardson's formular- 20 (K-R20) where the Correlation Coefficient (r) of 0.92 was obtained which was considered fit for the study. This formular was considered appropriate as it is applied to items that are dichotomously scored such as multiple choice items. Student in the experimental group were taught using concept mapping instructional strategy; while the control group were taught using lecture method.

The experimented group was subjected to concept mapping instructional teaching strategy while the control group was taught using lecture method. The treatment in each group lasted four weeks. The post-test stage was when the students were subjected to the test at the end of the treatment period. The data collected from both pre-test and post-test were statistically analyzed on the basis of the mean and standard deviation for answering the research questions while the null hypotheses were tested using t-test analysis at 0.05 level of significance.

Results

Research Question one: What is the difference in the mean achievement scores of the group taught acids base and salts through concept mapping and those taught using lecture method in Jalingo Education Zone of Taraba State.?

Table 1: Mean achievement scores and standard deviations of students taught acids, based and salts using Concept mapping and those taught using lecture method

Group	N	Pretest		Posttest		Mean Difference	Mean Gain
		Mean	Std.Dev.	Mean	Std.Dev.		
Experimental	62	21.03	6.91	42.68	5.95	21.65	
Control	88	21.68	7.33	26.89	7.35	5.21	
Mean Difference		- 0.65		15.79		16.44	16.44

The result in Table 1 shows that the post-test means achievement score of students taught acids, base and salts concepts in chemistry using Concept mapping is 42.68 with standard deviation of 5.95, while those taught using the lecture method is 26.89 with standard deviation of 7.35. The pre-test and post-test mean achievement scores difference for the two groups shows that the Concept mapping group scored highest. This suggest that students taught acids, base and salts concepts in chemistry using Concept mapping teaching strategy achieved higher than their counterparts taught using lecture method.

Research Question 2: What is the difference in the mean achievement scores of male and female students taught acids, base and salts using concept mapping Jalingo Education Zone of Taraba State?.

Table 2: Descriptive mean achievement scores of male and female students exposed to Concept mapping Teaching strategy in Chemistry

Gender	N	Pretest		Posttest		Mean Difference	Mean Gain
		Mean	Std.Dev.	Mean	Std.Dev.		
Male	29	21.66	7.03	43.72	4.80	22.06	
Female	33	20.48	6.86	41.76	6.74	21.28	
Mean Difference		1.18		1.96		0.78	0.78

Results of Table 2 shows that the pretest mean score of the male students taught acids, based and salts concepts in chemistry using Concept mapping is 21.66 with standard deviation of 7.03, while their posttest mean score is 43.72 with standard deviation is 4.80. The difference between the pretest and posttest of the male students is 22.06. In the same vein the Table shows that pretest mean score of female students is 20.48 with standard deviation 6.86, while their post-test mean achievement score is 41.76 with standard deviation of 6.74. The difference between the pre-test and post- test mean achievement scores of the female students is 21.28. The difference between the pretest mean scores of the male and female students is 1.18, while the difference between posttest mean scores of the male and female students is 1.96, all in favor of male students. Similarly, the difference between the mean differences (pretest and

posttest) is 0.78, also favors the male students. This suggests that male students taught using Concept mapping achieved higher than their female counterparts.

Hypotheses

H₀₁: There is no significant difference in the mean achievement scores of the group taught acids base and salts through concept mapping and those taught using lecture method Jalingo Education Zone of Taraba State..

Table 3: One way Analysis of Covariance of the mean achievement scores of the students taught acids, based and salts using Concept mapping teaching strategy and lecture method

Sources of variation	Sum of squares	Df	Mean Square	F	S	Partial eta squared
Corrected Model	11843.527 ^a	2	5921.763	213.313	.000	.744
Intercept	7130.543	1	7130.543	256.856	.000	.636
Pre-test	2773.566	1	2773.566	99.909	.000	.404
Group	9507.664	1	9507.664	342.484	.000	.700
Error	4080.846	147	27.761			
Total	183392.000	150				
Corrected Total	8051.246	149				

From table 3 above, the results of the main effects of methods of teaching chemistry on mean achievement score indicated by $F(1,147) = 342.484$ is significant at $p = .000 < .05$. The results affirms that there is a significant difference between the mean achievement scores of students taught chemistry using concept mapping strategy and those taught using lecture method. Thus, the hypothesis of no significance difference is not retained. The statistical significance ($\eta^2 = .700$) shows the actual difference in the mean scores between the groups is large. The effect size (eta square) shows that method of teaching is 70.0% responsible for the variance (difference) in the mean achievement scores of students.

Hypothesis Two

There is no significance difference in the mean performance scores of male and female students exposed to concept mapping learning strategy in chemistry in Jalingo Education Zone of Taraba State.

Table 4: Independent – Samples t – test of difference between male and female students taught chemistry using concept mapping

Achievement Score		Levene's Test for equality of variance		t-test for Equality of Means			Sig 2-tailed	Mean difference
		F	Sig	T	Df			
Equal variance assumed	variance	1.861	.178	1.306	60		.197	1.967
Equal variance not assumed	not assumed			1.334	57.66		.187	1.967

In Table 4, Levene's test for equality of variances was used to test whether the variance (variation) of scores for male and female is the same. The test shows that the variation is the same at 0.05 level of significance ($p = .178$). The independent – samples t-test conducted to compare the achievement scores shows that there is no significant difference in the post-test scores of male students ($M = 43.72$; $SD = 4.80$) and female students [$M = 41.76$; $SD = 6.76$; $(60) = 1.306$, $p = .197$]. The magnitude of the difference in the mean scores was small ($eta\ squared = t^2 / t^2 + (N - 2) = .028$). Thus, there is no statistically significant difference in the achievement scores of male and female students taught using concept mapping strategy.

Discussion of Findings

Effect of Treatment

The study examined the effect of Concept mapping teaching strategies on students' achievement in acids, base and salts in chemistry. The independent and moderator variables were methods (Concept mapping, and lecture methods) and gender, respectively. The results of the study show that students taught acids, bases and salts in Chemistry using Concept mapping out-performed or had higher mean achievement scores than their counterparts taught using lecture method. This is a confirmation that students in the three groups entered the instruction on equal strength. The result is in consonance with Okereke and Ezechukwu (2016), Ajewole and Ogunniyi (2018), Kayode (2023), Omeje (2024) who found that concept mapping instruction performed significantly better than the control group in a chemistry achievement. However, Duarte et al., (2017) in their studies found that students can generally have low level of assimilation using the concept maps methods especially when proper guidance is not provided. The finding, however, disagrees with that of Barchok (2014) whose study revealed that collaborative concept mapping has no effect on the learning outcomes of students.

Effect of Gender on Students Achievement

The study found that male students taught chemistry using concept mapping teaching strategy achieve higher than their female counterpart. However, the differences in the mean achievement score of male and female students were not significant. The implication of this finding is that there is no statistically significant difference in the achievement scores of male and female students taught chemistry using concept mapping strategy. Finding agrees with the assertion of Julius and Wachanga (2013); Ezeudu (2013) and Chawla (2015) that concept mapping strategy eliminates gender disparity in achievement as they found in their separate studies that gender does not affect students' chemistry achievement when they are taught using concept mapping. In corroboration, Agboola and Oloyede (2013) also earlier found that the gender of students has no effect on chemistry students' academic achievement when taught using concept mapping teaching strategy.

Conclusion

Based on the findings of this study, it can be concluded that concept mapping is a very effective learning strategy, It should, therefore, be used in secondary schools for teaching of chemistry concepts. It is also evident to conclude that gender has no significant influence on student academic. This study has, therefore, provided a fresh evidence to the body of knowledge on the effect of concept mapping on chemistry students' academic achievement in relation to gender of students.

Recommendations

This study investigated the effectiveness of concept mapping on secondary school chemistry students' achievement in Jalingo Education Zone of Taraba State. In view of the findings of this study, the following recommendations are made:

1. Pre-service and in-service Chemistry teachers should be trained on the use of Concept mapping teaching strategy and concept mapping should also be used by secondary school teachers in the teaching of chemistry in secondary schools since it is known to improve the academic achievements of students.
2. Gender should not be seen as a limiting factor on students' academic achievement as both male and female students have the ability to perform well when exposed to appropriate teaching methods such as concept mapping

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