



Enhancing Students' Achievement in Volumetric Analysis through concrete Exemplar Model in Colleges of Education in North -West Nigeria

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ABSTRACT

This study investigated the effect of Concrete Exemplar Model on Students academic performance in Volumetric Analysis concept among Federal Colleges of Education North West Zone, Nigeria. The study adopted pretest and posttest quasi experimental control group design. The population of the study comprised 718 (310 male and 408 female), all from the six Federal Colleges of Education in North- West Zone, Nigeria. The sample of one hundred and ten (110) NCE Chemistry students were purposively selected from two schools participated in the study. The schools were randomly assigned to experimental and control groups. The experimental group was exposed to concrete exemplar model while the control group was exposed to conventional laboratory teaching method. one validated instrument was used for data collection namely, Volumetric Analysis Performance Test (VAPT) with reliability coefficient of 0.73 was used to measure performance of Students. The reliability of the VAPT was determined using Pearson Product Moment Correlation Coefficient (PPMC) after test-retest method was applied. The Study was guided by two objectives, two research questions, and two hypotheses. Two research questions were answered using descriptive statistics of mean and standard deviation and two null hypotheses were tested at $p < 0.05$ level of significance. Data collected were analyzed using t-test statistic. The results among others revealed that (a) a significant difference in the mean performance scores of the experimental and control group ($p = 0.001 < 0.05$). Based on these findings it was concluded that students taught Volumetric Analysis concept using concrete exemplar model performed better than those taught same concept using conventional laboratory method. Furthermore, there was no significant difference between the performance of male and female students taught with concrete exemplar model. Based on these findings, the researcher recommended among others that, the use of concrete exemplar model should be encouraged among chemistry teachers at NCE level in teaching volumetric analysis concept to enhance students' performance.

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INTRODUCTION

In recent years, stake holders in science education have increasingly sought for innovative teaching strategies to promote students' engagement and learning outcome especially in subjects like biology, physics and chemistry

among others. Chemistry is regarded abstract and difficult for many students understanding. Among the instructional strategy that gain popularity and help student to learn chemistry concepts which are abstract is concrete exemplar model. This instructional strategy engages students with

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hands –on as well as in chemistry, a branch of science which also requires practical training to provide students with hand-on skills which allows them to have experience and expertise to gain greater understanding of their environment. Akpoghol, Ezeudu, Adzape and Otor (2016) contended that chemistry is a branch of science, which attained a unique position in the curriculum of secondary school as an essential part of general education for life. Despite its unique position in STEM and effort of researchers to improve its teaching and learning, student performance in the subject is still not encouraging and is observed to be declining (Ibrahim, 2019).

Udogu and Emendu (2017) pointed out that Chemistry teaching and learning can be appreciated through effective laboratory instruction. The laboratory activities avail students the opportunity to think creatively, ask reasonable questions, seek appropriate answers and solve problems. The instructions takes place in laboratories where both students and teachers carry out experiments and practical demonstration, thereby making Chemistry lessons Concrete and stimulating so as to enhance achievement of the students. This approach of learning and teaching chemistry makes it a practical subject. Practical work is encouraged in science subjects because it facilitates the learning and understanding of science concepts; and in developing competence in the skills and procedures of scientific inquiry. One of the concepts taught in practical class in volumetric analysis, therefore the study employed more engaging strategy to teach such concept in order to improve the students' academic performance.

Basically, Academic performance refers to students' academic outcomes after a specified sequence of instruction. Akaazua, Bolaji, Kajuru, Musa, and Bala (2017), posited that academic performance is an individual's grade in a specified content area or specified course of instruction after the individual or group has experienced training in a programme. It is supposed to test mastery of a laid – down curriculum after an instructional programme. Chemistry is seen as an important academic discipline in Nigerian school curriculum however it is plagued with problem of

poor performance. Failure in chemistry is commonly in the practical aspect, (Muhammad, 2021).

Poor Academic performance of student in chemistry was attributed to lack of use of laboratory method by teachers to teach practical chemistry among others. Poor teaching has been indicated as a major problem that results in candidates' poor achievement in chemistry mostly in external examination (NCCE, 2020). Udoh and Udo (2020) also state factor like, inappropriate understanding of the fundamental concepts in chemistry from the beginning of the lessons may have negative implications on student's achievement, abstract nature and difficulty of some concept which conventional instruction has little or no effect on them (Sewanu, 2022).

Stakeholders in education particularly the employers, and parent have the general feeling that the quality of science teachers produced by colleges of education at the NCE level is poor and their classroom performance is generally unsatisfactory. Umar (2018) revealed that poor performance of student teachers in the colleges can be anchored on teacher's classroom performance and pupils learning outcome. According to Umar (2018), this problem has become one of the most controversial issues in science education. "No educational system can rise above the quality of its teachers as stated in the "National Policy on Education; revised, Federal Republic of Nigeria (FRN, 2013). Chemistry as an experimental science subject demands a proactive teaching method with effective student involvement in hands-on minds-on experiences to generate knowledge; develop scientific skills, attitude and social values that would equip them to solve problems and contribute to national development (Udofia, 2017), therefore the researcher employed concrete exemplar model to teach student so as to improve meaningful learning.

Concrete exemplars are tools used to facilitate student's comprehension through use of real materials. These are ideal materials that are presented in such a way to help student learning material in logical step by step sequences which are concrete, guided with adjunct questions in



text. Ozogul and Reisslein (2011) stated that concrete visual representations illustrate the real-life object corresponding to a problem cover story. Felix, Korhonen and Christian (2014) added that concrete concepts are more easily learned, remembered, easily processed and students understanding can also be catalyzed through concrete media.

According to Ojose (2015) hands on activities are important so as to provide students an avenue to make abstract ideas concrete. Hayat, Ahmad and Khan (2024) describe hands on experiences and multiple ways of representing a mathematical solution as ways of fostering the development of the cognitive skills in student learning abstract concepts. Abstract nature of chemistry makes student avoid answering questions from certain areas or perform poorly if attempted in Examinations. Abdulsalam (2020) asserted that scientist and science teachers often develop tangible materials in communicating ideas that are abstract to students in a more concrete way in order to enhance comprehension. These prompted the researcher to use concrete exemplar model as teaching strategy in order to improve students' performance, as well as address the learning outcome in gender.

Gender is one of the factors for student's academic performance in science learning processes. Some researchers such as Opara and Waswa (2013) reported no gender difference in the performance of boys and girl in learning cycle. While researchers like, Filgona and Sababa (2017), Hassan (2023) supported those female students had greater influence on students' performance towards chemistry than their male counterpart. In the same vein, Chikendu (2018), Kareem (2019), Ekundayo (2022), Nwafor, Joshua and Ezeanya (2023) are of the view that attitude and behavior of teachers tend to favors male student than the female, thereby making the male to be more competent and perform better while female are seen weaker sex and it affect their performance in science. Therefore, this study investigated whether the use of concrete exemplar model is gender friendly or not.

STATEMENT OF THE PROBLEM

Chemistry is a core science subject that plays a vital role in preparing students for careers in medicine, pharmacy, engineering, and other scientific fields. Despite its importance, students in Nigerian Colleges of Education, particularly in the Northwest zone, continue to perform poorly in chemistry. One of the concepts that students find most difficult is Volumetric Analysis, due to its abstract nature and the heavy reliance on conventional teacher-centered laboratory methods. These traditional methods often reduce students to passive observers, limiting their ability to engage in practical, hands-on learning.

Empirical evidence suggests that poor performance in chemistry is linked to ineffective instructional strategies that fail to bridge the gap between abstract concepts and students' concrete experiences (Udoh & Udo, 2020; Sewanu, 2022). Although the National Policy on Education emphasizes quality science teaching, many chemistry educators still lack innovative approaches that actively engage learners in the laboratory. As a result, students struggle to develop conceptual understanding, practical skills, and confidence in handling laboratory tasks, which ultimately affects their academic achievement.

The Concrete Exemplar Model (CEM) has been identified as an innovative instructional strategy capable of making abstract concepts more meaningful by providing tangible, hands-on experiences. However, little is known about its effectiveness in teaching Volumetric Analysis at the College of Education level in Nigeria. Moreover, gender differences in learning outcomes under this model remain underexplored. Addressing this gap is critical for improving chemistry learning outcomes and ensuring equitable participation of both male and female students. Therefore, this study investigates the effect of the Concrete Exemplar Model on students' academic performance in Volumetric Analysis among Federal Colleges of Education in Northwest Nigeria, with a view to determining its effectiveness compared to conventional methods and its gender inclusiveness.

Objectives of the Study

The objectives of the study are to:

1. find out the difference between the mean performance scores of NCE I students taught Volumetric analysis using Concrete exemplars and those taught using conventional laboratory method.
2. find out the difference between the mean performance scores of male and female NCE I students taught Volumetric analysis concept using Concrete exemplars and those taught using conventional laboratory method.

Research Questions.

For the purpose of this study, the following research questions were raised.

1. What is the mean difference between academic performance scores of NCE I students taught volumetric analysis concept using concrete exemplar's model and those taught using conventional laboratory method?
2. What is the difference between the mean academic performance scores of male and female NCE I students taught volumetric analysis concepts using concrete exemplars model?

Null Hypotheses

The following null hypotheses are formulated for testing the research questions at $p \leq 0.05$ level of significance:

- Ho₁: There is no significant difference between the mean academic performance scores of NCE students taught volumetric analysis concept using concrete exemplar Model and those taught using Conventional laboratory method.
- Ho₂: There is no significant difference between the mean academic performance scores of NCE one male and female students taught volumetric analysis concepts using concrete exemplars model.

METHODOLOGY

The study was carried out using Quasi Experimental - Control group design involving pre-

test and post-test control design. A quasi-experimental design is often used in a classroom experiment and does not involve the random assignment of participants into treatment groups. The study involves a control group and an experimental group consisting of both male and female students. A pre-test was administered to the groups using Volumetric Analysis Performance Test (VAPT) to determine the group equivalence before the commencement of the treatment.

Experimental group was taught volumetric analysis concept using Concrete Exemplar Model. The control group was also taught the same concept using conventional laboratory method for a period of six weeks. At the expiration of six weeks treatment schedule, all the participants in the two groups were post-tested using the same instrument that was used for pre - test in order to observe if there is any significant difference in their mean score. The scores obtained was analyzed to determine the effectiveness of the treatment. Population for the study comprises of all NCE Chemistry Students from Federal Colleges of Education in Northwest Nigeria which has six (6) Federal Colleges of Education with a total of 718 students comprising of 310 male and 408 female students.

Two schools were randomly selected and used as experimental and control groups. The first school picked was tagged experimental group while the second school was tagged control group. A total sample of 110 students was selected using purposive sampling technique from the population of the study. The course combination selected was Chemistry/Integrated Science NCE . due to management size which the study demand in terms of materials and equipment, also integrated science course have element of other discipline of sciences that cut across chemistry, biology and physics (Usman,2021).

The Volumetric Analysis Performance Test (VAPT), is a forty (40) items objective test involving multiple choice test questions with four options (a, b, c, and d) which was adapted from NCE past examination question paper for 3-5 years (2018-2020) and was subjected to conform the standardization, to measure students'

academic performance of NCE students. The question includes one correct and three distractors which each question answered correctly is awarded 1 mark, corresponding with the 40 items making a total of 40 marks. The items were prepared based on Blooms Taxonomy of Cognitive domain to ensure that the test covers all level of cognitive domain of students which was adapted from Blooms Taxonomy of educational objectives (1964).

Content validity was ensured through expert review. Experts from Science Education department and department of Chemistry. Ahmadu Bello University, Zaria, with a minimum qualification of PhD. Critically examined the Volumetric Analysis Performance Test (VAPT) to confirm their relevance, clarity, and alignment with the specified curriculum objectives. Their feedback guided necessary revisions to improve the instruments quality. To determine the reliability of the VAPT, test-retest method using Pearson Product-Moment Correlation Coefficient statistic was employed. The reliability of the instrument was determined after pilot-test. The r value recorded for the VAPT was 0.73 which was considered acceptable for measuring internal

consistency. The data was collected using the research instruments named Volumetric analysis performance Test (VAPT). Two types of data were collected during this research work. These are: Pretest (before the treatment) to ascertain their group equivalence and post-test (after the treatment) to ascertain their performance and level of conceptual understanding determine the effectiveness of the treatment. The student's responses were marked and collated. Afterward the data generated from the score was subject to statistical analysis.

RESULTS

Research Question One:

What is the mean difference between academic performance score of students taught volumetric analysis concept using concrete exemplar's model and those taught using conventional laboratory method at NCE?

In order to answer research question one, the posttest scores of students in the experimental and control groups are presented in Table.1.

Table. 1: Mean and Standard Deviation of Performance Scores of NCE I Students in Experimental and Control Groups

Variable	Groups	n	Mean	STD	Mean difference
Academic Performance	Experiment	45	31.84	4.32	18.03
	Control	65	13.81	2.99	

Table.1 showed the mean academic performance score of 31.84 and 13.81 for experimental students taught volumetric analysis concept using concrete exemplar Model and the control group students taught using Conventional laboratory method respectively, indicating a mean difference of 18.02 in favour of the experimental; students taught volumetric analysis concept using concrete exemplar Model. This shows that remarkable difference exists in the mean Academic Performance score of NCE students taught volumetric analysis concept using concrete exemplar Model and those taught using Conventional laboratory method.

To determine the mean difference is significant or not. Hypotheses one was formulated and tested.

Null Hypothesis One:

There is no significant difference between the mean Academic Performance score of NCE I students taught volumetric analysis concept using concrete exemplar Model and those taught using Conventional laboratory method.

The posttest scores of students in the experimental and control groups were subjected to an independent samples t-test as presented in Table 2.

Table 4.2: Summary of Independent t-test Analysis of Mean Performance Scores of NCE I Students in Experimental and Control groups

Variable	Groups	n	Mean	STD	Df	t-value	P
Academic Performance	Experiment	45	31.84	4.32	108	25.880	0.001
	Control	65	13.81	2.99			

Significant at $P < 0.05$ level

Table 2 shows the outcome of the independent t-test statistics revealed that significant difference exists between the mean academic performance score of NCE I students taught volumetric analysis concept using concrete exemplar model and those taught using conventional laboratory method with mean scores of 31.84 and 13.81 respectively. This was because the calculated p value of 0.001 was lower than the 0.05 alpha level of significance. Hence, it was in favour of the experimental students taught volumetric analysis concept using concrete exemplar Model. Therefore, the null hypothesis which state that there is no significant difference between the mean academic performance score

of NCE I students taught volumetric analysis concept using concrete exemplar Model and those taught using Conventional laboratory method, was hereby rejected.

Research Question Two:

What is the difference between the mean academic performances scores of male and female NCE I students taught volumetric analysis concepts using concrete exemplars model?

The posttest performance scores of male and female students in the experimental group were used to answer research question four as presented in Table 3

Table 3: Mean and Standard Deviation for Academic Performance Scores of Male and Female NCE I Students in the Experimental Group

Variable	Gender	n	Mean	Std	Mean difference
Academic Performance	Male	25	31.72	4.39	1.28
	Female	20	32.00	4.33	

Table 3 shows that there was no significant difference in mean academic performance scores of male and female NCE I students taught volumetric analysis using concrete exemplar model. Their mean academic performance scores are 31.720 and 32.00 by experimental male and female NCE I students taught volumetric analysis using concrete exemplar model respectively, indicating an insignificant mean in conceptual understanding difference of only 1.28. On the basis of gender

status, the concrete exemplar model was gender friendly on mean academic performance scores. In order to find out if the mean difference was significant or not, hypothesis two was formulated and tested as presented in Table 4.

Null Hypothesis Two:

There is no significant difference between the mean academic performance scores of NCE I male and female students taught volumetric analysis concepts using concrete exemplars model

Table 4: Summary of Independent t-test Statistics for Difference Mean Academic Performance Scores of Male and Female NCE I Students in the Experimental Group

Variable	Gender	n	Mean	STD	Df	t-value	P
Academic Performance	Male	25	31.72	4.39	43	0.21	0.83
	Female	20	32.00	4.33			

Not Significant at $P > 0.05$ level

Table 4. shows the outcome of independent t-test statistics which revealed that there is no significant difference in mean academic performance scores of Male and Female NCE I Students taught Volumetric Analysis using Concrete Exemplar Model. This is because the calculated p value of 0.83 is greater than the 0.05 alpha level of significance. On the basis of gender status, the Concrete Exemplar Model is gender friendly on mean academic performance scores. Therefore, the null hypothesis which state that There is no significant difference in the academic performance of Male and Female NCE I Students taught Volumetric Analysis using Concrete Exemplar Model is hereby accepted and retained.

DISCUSSION OF FINDINGS

The Study examined the effects of concrete exemplar model on Students' Academic Performance in Volumetric Analysis among Colleges of education Northwest Nigeria. Two Null hypotheses were tested. The result showed that Students taught, using Concrete exemplar model performed better than those taught using conventional laboratory method. This shows that the method of instruction was effective in enhancing academic performance. For example, Ogunleye (2017); Akaazua (2017); Abdullatiff et al (2017); Moffet (2018); Micallef and Newton (2022); Kelechi and Omeodu (2018), who discovered that Students working with Concrete model approach performed significantly better than those with conventional method.

The performance of those taught with Concrete model approach have been engendered by the opportunity that members interact with concrete material where, they handle material which made the students to obtain some skills and

have better grasp of the concepts which enhanced their performance. Furthermore, finding of this study disagree with the findings of Sumerekti et al (2019) who reported no statistically significant relation between the academic performance and Concrete examples. This non conformity shows that Students cannot further transfer their understanding of principle behind a concrete example to another concrete situation that appear to be different on the surface but relies on the same abstract principle. Thus, indicated that one example is not enough for students to preform excellently in the classroom.

A significant difference exists in the mean performance Score of NCE I Students taught volumetric analysis concept using concrete exemplar model and those taught using conventional laboratory method. This could be as a result of the students centered nature of the teaching model used. The finding of this Study is a conformation of the findings of Ogunleye (2019), Mahayukti et al (2019), and Obioha (2020) who have provided that there is significant difference in academic performance of Students. This could be attributed to the use of students centered approach while teaching. However, it is not in conformity with the finding of Sumerecki et al (2019) who reported no significant difference in the performance of students. This non conformity could be as a result of the subject matter that were taught.

Centered on gender related difference in academic performance in relation to the variables of Study. The results Showed that there was no significant difference in mean academic performance Scores of male and female concrete operational Students with reference to gender. Thus, the concrete exemplar model favours both male and female Students equally in the learning of volumetric analysis concepts. This fact that

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neither the male nor the female performed significantly better than the other seems to make the method gender friendly. This finding is in agreement with Tambaya et al (2016), Diana (2014) and Mari (2012). It was in disagreement with Adigun et al (2015), Kola (2020) and Obioha(2020) who reported that gender of students does not influence their performance in volumetric analysis with the male Scoring higher in the performance Score. This could be as a result of teaching Strategy employed, location and Subject matter that was taught.

CONCLUSION

The findings of this study demonstrated that students taught volumetric analysis using the Concrete Exemplar Model significantly outperformed those taught with conventional laboratory methods. This aligns with Constructivist Learning Theory, which emphasizes active learner engagement in constructing knowledge through hands-on activities. By manipulating concrete examples, students developed personal meaning from abstract chemical concepts, making learning more authentic and sustainable.

Furthermore, the results support Kolb's Experiential Learning Theory, which posits that knowledge is created through the transformation of experience. The CEM provided students with concrete experiences in volumetric analysis, which facilitated reflective observation and abstract conceptualization, ultimately enhancing their ability to apply concepts during assessment. The positive performance outcomes also resonate with Dual Coding Theory, where learning is strengthened when verbal explanations are combined with visual or physical representations. The concrete exemplars acted as cognitive anchors, enabling students to encode and retrieve information more effectively than those exposed to abstract teaching alone.

Finally, the absence of significant gender differences suggests that the CEM is gender-inclusive, offering equal opportunities for both male and female learners to engage meaningfully with abstract chemistry concepts. This reinforces the argument that constructivist,

student-centered pedagogies can help close equity gaps in science education.

RECOMMENDATIONS

1. Federal colleges of Education in Northwest Nigeria should adopt a gradual and phased approach to implementing the concrete exemplar model strategy in chemistry instruction, beginning with pilot classes before scaling up to a wider adoption.
2. The use of concrete exemplar Model in teaching volumetric analysis concept among chemistry teachers should be encouraged through constant supervision and monitoring.

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