

Effect of Concrete-Exemplar Model on ... Madaki. S. M., Et. al. (2025)

Effect of Concrete-Exemplar Model on Conceptual Understanding of Volumetric Analysis Concept among Federal College of Education Students in North-West, Nigeria

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Abstract

*This study Effect of Concrete-Exemplar Model on Conceptual Understanding of Volumetric Analysis Concept among Federal College of Education Students in North-West, Nigeria. The study adopted pretest and posttest quasi experimental control group design. The population of the study comprised 718 (310 male and 408 female) NCE I Chemistry students from all the six Federal Colleges of Education in North- West, Nigeria. The sample of one hundred and ten (110) NCE Chemistry students were purposively selected from the target population. The experimental group was exposed to concrete exemplar model while the control group was exposed to conventional laboratory teaching method. Chemistry Conceptual Understanding Inventory (CCUI) with reliability coefficient of 0.80 respectively used to measure conceptual understanding of Students on the concept volumetric analysis. Cronbach's Alpha reliability coefficient test. The Study was guided by two objectives, research questions, and corresponding null hypotheses, respectively. Two research questions were answered using descriptive statistics of mean and standard deviation and two null hypotheses were tested at $p \leq 0.05$ level of significance using *t*-test inferential statistics. The results among others revealed a significant difference between the conceptual understanding of experimental group and control group ($p = 0.01 < 0.05$). Based on these findings it was concluded that students taught Volumetric Analysis concept using concrete exemplar model had better conceptual understanding of the concept than those taught same concept using conventional laboratory method. The study, therefore 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' meaningful learning and conceptual understanding.*

Keyword: Concrete exemplar, Conceptual Understanding and Volumetric Analysis

Introduction

Chemistry is a branch of science which requires practical training to provide students with skills which allows them to have experience and expertise to gain greater understanding of their environment. Akpoghol, Ezeudu, Adzape and Otor (2016) pointed out that the combination of chemistry and chemists to social, industrial and economic life of the world in general and Nigeria in particular have been felt on all phases of human life. Akpoghol et al (2016) further stress that the knowledge of chemistry has enabled the provision of good water, food, and healthcare delivery, various materials for construction in industries, roads, automobiles, and houses. Chemistry is used in solving problems resulting from human interaction with the environment like water and pollution. Furthermore, despite the relevance of the knowledge of chemistry to the society, achievements of students in chemistry as measured by their scores in school certificate examinations have been very poor. This according to Diah (2018) is as a result of the misconception they hold in some Science related subject at Secondary School level. These misconceptions are carried along with to the College of Education as well as Universities. The



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misconceptions are basically in certain concepts which are abstract in chemistry, such as electrochemistry, balancing of chemical equations and mole concept among others. Basically, importance of understanding mole concept cannot be overemphasized. Over the years chemistry student in Colleges and institutions of higher learning have poor concentration and understanding of these concept due to lack of interest, and abstract nature of the concepts (Aklan, 2021), and lack of practical skills, as a result of inexperience in their ordinary level, where most Nigerian schools lack laboratory facilities (Agahu et al, 2020), and ineffective teaching methods used by the teachers. In order to boost students learning outcome, practical skills are required in mole concept and volumetric analysis inclusive. Practical skills are crucial for success in science courses, practical activity is important as the theoretical aspect is. Nelson (2019) stated that most chemical operations require considerable practical skills and no amount of intellectual understanding can substitute for that aspect, it is therefore very vital for the learners to acquire significant practical skills that will enable them solve problems in this regard, more especially in volumetric analysis among others.

Volumetric analysis is a method of quantitative analysis which is based on mole concept, it requires skills in practical and it involves accurate measurement of volumes of liquids, i.e., analysis of the amount of substance present. In volumetric analysis, the amount of solute present in an aqueous solution is determined by allowing a sample volume of this solution to react completely with another solution of known strength or composition. The process involves accurate measurement of the sample volume and noting the exact amount of the unknown solution needed to react thoroughly with the first. Campbell, Midson, Bergstrom, Cahill and Steward (2022) noted that Chemistry laboratory practical are designed to fit within the traditional discipline boundaries. Therefore, students usually miss the opportunity to make connections between different areas of Chemistry. Abu and Mathew (2021) reported that the practice in most Nigerian schools is students are allowed to perform experiment in “cook book” fashion where by student only follow direct instructions, without proper understanding. According to Adegoke (2021), inadequacy of basic laboratory materials, technical personnel and persistent use of conventional laboratory methods among other factors, significantly obstructed the effective teaching of chemistry practical. These conventional methods are considered ineffective for teaching volumetric analysis leading to misconception. Consequently, this study employs a concrete exemplar model to teach the concept, with the aim of making learning meaningful and promoting deeper conceptual understanding.

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. Many educators such as Stephen (2023) and Ojo (2017) argue that concrete material help student think, reason and solve problems. Concrete material may offer a boost on a direct-test of knowledge. Shing (2016) view science as concrete operational and formal operational concept accordingly, the concrete operational concepts are concepts whose meaning can be developed from firsthand experience with object or events and formal operational concepts are concepts whose meaning are given through imagination or through logical relationship with the system. Mari and Samuel (2023) also reported that certain formal concepts can be comprehended by students when they are taught using hands on method, analogies, concrete material and diagrams among others, which are among activity-oriented strategies. According to Federal Ministry of Education in the National Policy on Education (FRN, 2013) stipulated that number of activity oriented instructional strategies have been advocated for, by curriculum designers and science educators to help improve students’ performance among college science students. Examples include guided discovery, concept mapping, inquiry and use of concrete material among others. Stephen (2023) lamented that the best approach in teaching for conceptual understanding is through presentation of the real objects in the learning units. The idea is to ground the abstract symbols in appropriately structured environments so that the student can use the environment to help guide their thinking. Herron (2017) observed that once concrete materials are used in instruction as often done in inquiry learning, students can be expose to concepts no matter how abstract minded concrete props which model abstract concepts are used. Ojo (2017) supported the use of concrete material to boost students understanding in chemistry concepts. 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. Therefore, the study employs concrete exemplar model to promote students conceptual understanding.



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Conceptual understanding is the ability to explain concept taught in one's own words or ways having understood it well. Herron (2017) views Conceptual understanding as the ability to relate abstract ideas to concrete phenomena and also transferring knowledge to new situation and context. Holmes and co-workers (2015) stated the goal of instructors in general chemistry is to promote student conceptual understanding to achieve better in sciences. Mill (2016) sees conceptual understanding as frames of thinking, in which concepts when elaborated into generalization will be for conceptual understanding. Cracolice, Deming and Ehlert (2008) added that teachers focusing on teaching for conceptual understanding rather than memorizing of facts and topic, it provides a frame for thinking which allow learners for in-depth understanding of phenomena and will enable them connect to more advanced ideas rather than memorization of facts. Moreover, science educators have realized teaching science as a list of fact for memorization rather than for understanding is a futile exercise. Gongden (2015) revealed that research in science has shifted from teacher-centered to student-centered, and also on factors in students' mind such as prior-knowledge, misconceptions, memory capacity and cognitive style. Teaching should not be for examination only as is presently the case; rather it should encourage thinking on the subject and nurture innovation and creativity while retaining the excitement of chemistry. Teachers should motivate and inspire students, should also ensure that whatsoever is taught, is effectively learnt by the students in promoting conceptual understanding in student, learning does not mean rote learning rather should be built on the students' acquisition of knowledge and understanding of scientific phenomena (Muhammad, 2021).

Conceptual understanding of scientific phenomena is essential to lay solid foundation of basic chemistry concepts as indicated in the hierarchy of learning. Emerhiona (2021) asserted that one of the major weaknesses of students that lead to poor performance is lack of basic understanding of simple chemistry concepts. According to Bankole and Oludipe (2020) Chemistry are perceived difficult and abstract to learn, such concepts identified as difficult includes; Mole concept, Redox reactions, Volumetric Analysis, electrolysis, chemical equations among others. Volumetric analysis is among such concepts in the minimum standard of National Commission for Colleges of Education (NCCE, 2020) which is the focus of this research, as a result of its usefulness and relevant to our daily lives (Eya, 2015). Moreover, questions are set on the concept by external examination bodies yearly and students are not properly grounded in the basic concepts. The lack of understanding concepts in chemistry may be attributed to the use of conventional laboratory method in practical work whereby by chemistry teachers dominates the scene preferably demonstrating it and give only formula with cooked values. Learners are inactive, also making little or no room for challenging learners' ingenuity and development of cognitive skill through experiment (Bankole et al, 2020). These prompted the researcher to use concrete exemplar model as teaching strategy in order to improve students' conceptual understanding, as well as address the learning outcome in gender. Gender is one of the factors for student's understanding of concepts in science learning processes and gender is important in educational system as it influences the curriculum, instructional strategy, and understanding among others. Some researchers such as Atamonokhai, Adikwu, Ochu and Iji (2017) indicated that gender stereotyping is reduced as both boys and girls participate actively in groups without any form of discrimination or segregation. While researchers like, Filgona and Sababa (2017), Hassan (2023) supported that female student had greater influence on students' performance towards chemistry than their male counterpart using mastery learning strategies. In the same vein, Mari (2012) also views boys to be more discovering, active and problem solver than their female counterpart. Therefore, this study investigated whether the use of concrete exemplar model is gender friendly or not.

Despite the vital role of volumetric analysis in chemistry education, many students in Federal Colleges of Education in Northwest Nigeria often struggle with poor conceptual understanding of this topic. This persistent challenge has been attributed to the continuous use of conventional laboratory methods, inadequate laboratory facilities and the lack of hands-on approach, among others. Traditional approaches are often abstract and fail to bridge the gap between theory and practice, resulting in low learning outcome. Recent studies suggest that incorporating concrete models into science instruction can significantly enhance students' conceptual understanding and meaningful learning. For instance, Ojoko et al (2023) found that the use of teacher-constructed concrete models significantly improved students' conceptual level in Basic science and technology class. Similarly, Onunkwo, Ozomodu, Ejikeme and Osuji (2025) found that the use of concrete models significantly improved students understanding and performance in unsaturated hydrocarbon in chemistry. These findings suggest that concrete exemplar models may offer an effective alternative for improving conceptual understanding in



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chemistry. Therefore, this study seeks to examine the effect of concrete exemplar models on students' conceptual understanding of volumetric analysis in federal colleges of education in Northwest, Nigeria.

Objectives of the study:

The following objectives guided the study:

1. find out the difference between the Conceptual understanding of NCE I students taught Volumetric analysis using Concrete exemplars and those taught using conventional laboratory method
2. find out the difference between the conceptual understanding of male and female NCE I students taught volumetric analysis 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 conceptual understanding of NCE I students taught volumetric analysis concept using concrete exemplar's model and those taught using conventional laboratory method?
2. What is the mean difference between the Conceptual Understanding of male and female NCE I students taught using Concrete Exemplar Model?

Hypotheses:

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

1. There is no significant difference between conceptual understanding of NCE I students taught volumetric analysis concept using concrete exemplar strategy and those taught conventional laboratory method.
2. There is no significant difference between conceptual Understanding of Male and Female NCE I Students taught Volumetric Analysis using Concrete Exemplar Model.

Methodology

The study was carried out using Quasi Experimental - Control group design involving pre-test and post-test control design. Two groups were used for data collection; the experimental (ExG) and the control group (CnG). A pretest was administered to the two groups using Conceptual Understanding Inventory to determine the group equivalence before the commencement of the treatment. Experimental group was taught volumetric analysis concept using Concrete Exemplar Model while 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. Population for the study comprises of all NCE I 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. A total sample of 110 students were selected using purposive sampling technique from the population of the study. Chemistry conceptual understanding inventory was the instrument used to collect data for the study.

Chemistry Conceptual Understanding Inventory (CCUI): is an instrument adapted and modified from Mari (2019) which involves testing the level of conceptual understanding of the students, it is a research-based assessment instrument that measures conceptual understanding, it is an open-ended assessment that was developed following a rigorous research process. The test consisted of ten (10) items requiring Student to give a brief answer to the questions and reasons why that answer was given also provide explanation to the phenomenon presented in question. Concept inventory differs from assessment-test as it is aimed at examining conceptual understanding, it may not cover detailed content knowledge. It is based on rigorous research into student misconceptions, and questions were often worded to reflect common students' misconception. Concept inventory are usually given at the beginning of a course (pretest) to gain a sense of Students prior knowledge, and also given at the end of the course (Posttest) to gauge changes in the students' understanding. The content validation of the CCUI was carried out by experts, that is, two lecturers, one professor from psychology Department and one professor in Science Education Department, both from Ahmadu Bello University, Zaria. In order to ascertain the level to which CCUI was reliable. Data collected from the pilot test were analyzed using Cronbach Alpha. The result showed a reliability coefficient of 0.80 which was considered reasonably reliable for this study. Two null hypotheses were tested at 0.05 level of significance. The data collected were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (t-test).



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Presentation of Results

Research Question 1

What is the difference between the conceptual understanding of NCE I students taught volumetric analysis concept using concrete exemplar Model and those taught using Conventional laboratory method?

The posttest scores of conceptual understandings of students in the Experimental and Control Groups were used to answer the research question as presented in Table 4.3.

Table 1: Mean and Standard Deviation in Conceptual Understanding of NCE I Students for Experimental and Control groups

Variable	Groups	n	Mean	STD	Mean difference
Conceptual understanding	Experiment	45	19.91	13.32	5.31
	Control	65	14.60	6.40	

Table 1 showed the mean scores in conceptual understanding of 19.91 and 14.60 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 in conceptual understanding difference of 5.31 in favour of the experimental students taught volumetric analysis concept using concrete exemplar. This shows that difference exist between the conceptual understanding of NCE I students taught volumetric analysis concept using concrete exemplar Model and those taught using Conventional laboratory method.

Research Question Two: Is there difference between conceptual Understanding of Male and Female NCE I Students taught Volumetric Analysis using Concrete Exemplar Model?

Table 2: Mean and Standard Deviation of Male and Female NCE I Students in the Experimental and Control groups

Variable	Gender	n	Mean	STD	Mean difference
Conceptual understanding	Male	25	17.32	1.89	1.17
	Female	20	16.15	1.81	

Table 3 showed the mean in conceptual understanding of 17.32 and 16.15 for male and female NCE I students in the experimental group taught Volumetric Analysis using Concrete Exemplar Model respectively, indicating an insignificant mean between conceptual understanding difference of only 1.17. This shows that there was no relative difference in the conceptual Understanding of Male and Female NCE I Students taught volumetric analysis using concrete exemplar model. On the basis of gender status, the concrete exemplar model was gender friendly.

Hypothesis 1

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

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

Table 3: Summary of Independent t-test Statistics in Conceptual Understanding of Students in the Experimental and Control groups

Variable	Groups	n	Mean	STD	Df	t-value	P
Conceptual understanding	Experiment	45	19.91	13.32	108	2.784	0.01
	Control	65	14.60	6.40			

Significant at $P \leq 0.05$ level

Table 3 shows the outcome of independent t-test statistics which revealed that significant difference exists between the conceptual understanding of NCE I students taught volumetric analysis concept using concrete exemplar model and those taught using Conventional laboratory method. This is because the calculated p value of 0.01 is lower than the 0.05 alpha level of significance and it was in favour of the experimental; students taught volumetric analysis concept using concrete exemplar model. Therefore, the null hypothesis which stated that there is no significant difference between the mean



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

There is no significant difference between the conceptual Understanding of Male and Female NCE I Students taught Volumetric Analysis using Concrete Exemplar Model

The posttest scores of male and female students in conceptual understanding taught Volumetric Analysis using Concrete Exemplar Model were subjected to an independent samples t-test as presented in Table 4.

Table 4: Summary of Independent t-test Statistics in Conceptual Understanding of Male and Female NCE I Students in the Experimental Group

Variable	Gender	n	Mean	STD	df	t-value	P-value
Conceptual understanding	Male	25	17.32	1.89	43	0.79	0.43
	Female	20	16.15	1.812			

Not Significant at $P > 0.05$ level

Table 4 shows the outcome of the independent t-test statistics of male and female students' conceptual understanding after exposure to concrete exemplar model. The table revealed that there was no significant difference in the conceptual understanding of male and female NCE I students taught volumetric analysis using concrete exemplar model. This was because the calculated p value of 0.43 is greater than 0.05 alpha level of significance. On the basis of gender status, the Concrete Exemplar Model was gender friendly. Therefore, the null hypothesis which stated that there is no significant difference between the conceptual understanding of male and female NCE I Students taught Volumetric Analysis using Concrete Exemplar Model was hereby accepted and retained.

Discussion of Findings

The findings of this study showed that conceptual understanding of Students taught using Concrete exemplar model, was better than those taught using conventional laboratory method. This shows that the method of instruction was effective in enhancing meaningful learning and also correct the misconception they hold. Significant difference was found to exist in conceptual understanding of NCE I Students taught volumetric analysis concept using concrete exemplar model and those taught using conventional laboratory method which means that concrete exemplar model promotes conceptual understanding in volumetric analysis. The significant improvement in the conceptual understanding was due to the effective of treatment. The students in experimental group improve their conceptual understanding after exposure to treatment. This findings agree with Nwakaego (2018), Aminu (2015), Emerhiona (2021), Bawa et al(2020), Bankole and Oludipe (2020),but disagree with Demircioghe (2017), Onder (2017) and Kara and Kayacan (2023).The observe significant difference in conceptual understanding of experimental group in this study are attributed to a large extent to interaction offered by tangible materials, which Students get fun learning experience and are train for creativity because it involve concrete objects, which later the students can relate and transfer the concepts in abstract stage Delvi observed that for students to understand basic concepts, Students must learn abstracts concepts in concrete things first. No Significant difference in the conceptual understanding of male and female taught volumetric analysis concepts using concrete exemplar model. This result reveals no Significant difference in conceptual understanding of the male and female in the experimental group. This means that the conceptual understanding of the students when taught volumetric analysis concepts in Chemistry using concrete exemplar model is not significantly affected by gender. This finding is in agreement with the findings of Onder (2017), Aminu (2015), and Ayuba (2014), but disagree with Kola (2020) and Obioha (2020) as the observed male are superior in conceptual understanding than their female counterparts due to the observed fact that male learn how to think critically and can apply knowledge flexibly (Sigler and Sam,2006).

Conclusion

Based on the findings of this study it was concluded that concrete exemplar model was able to enhanced students' conceptual understanding in volumetric analysis because students are exposed to laboratory material, they manipulate and carryout activities by themselves while the teacher serve as facilitator and they brainstorm on their findings among themselves while conventional laboratory approach teacher demonstrate how to carry out the practical to students without active participation of student thereby making teacher active and student passive. The effect of the instructional strategy



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was also found to vary with gender of students, which implies that the conceptual understanding taught using concrete exemplar model is not in any manner affected by their gender.

Recommendations

Based on the findings of this study, the following recommendations are put forward:

1. The use of concrete exemplar Model in teaching volumetric analysis concept among chemistry teachers should be encouraged through constant supervision and monitoring
2. There is need to improve teachers' pedagogy so as to improve the student conceptual understanding of the volumetric analysis concept in schools by supporting the teachers
3. Teachers should be motivated both intrinsically and extrinsically through remuneration, promotions and sponsorship to trainings and workshops

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