EFFECTS OF RELEVANT MATHEMATICS CONCEPTS' PRIOR KNOWLEDGE ON VOLUMETRIC ANALYSIS IN CHEMISTRY AMONG SECONDARY SCHOOL STUDENTS IN MINNA EDUCATIONAL ZONE, NIGER STATE

LASISI NURENI[1], OMOBOLANLE ARIKE FATUSI[2], CHADO, A. M[1].
[1]Department of Science Education, Federal University of Technology Minna, Niger State; +2349032242838
[2]Department of Science Education, National Open University of Nigeria, Headquarter Jabi-Abuja; afatusi@noun.edu.ng

Abstract
This work investigated the effects of relevant mathematics concepts prior knowledge on volumetric analysis in chemistry among secondary school students in Minna Educational Zone, Niger State, two objectives were stated to guide the study which was translated to two research questions and null hypotheses. The research design adopted for this work was quasi experimental research design. Three sampling techniques were used to sample 349 students from six school, three schools for experimental group and three schools for control group. The research instrument used for data collection was Chemistry Achievement Test (CAT) developed by the researcher and validated by six experts in the field of chemistry education. Chemistry achievement test was pilot tested on 15 chemistry students which are part of population but not sampled for the real study the data gathered was analyzed using Kuder Rechardson 21 which yielded 0.78 which shows that the instrument is reliable. Chemistry Achievement Test (CAT) was used to collect data from Chemistry students. The data collected was analyzed using descriptive and inferential statistics. Mean and standard deviation was used to answer the two research questions and independent t-test was used to test the null hypotheses at alpha level of 0.05. The analyses showed that both groups benefited from the treatment but experimental group had higher mean gain, There was significant difference in the hypothesis one in favour of experimental group. There was no significant difference in the achievement of male and female students taught relevant mathematical concepts before learning volumetric analysis which shows that method is gender friendly. The researcher concluded that learning relevant mathematical concepts before teaching volumetric analysis is very important and it can be applied in any class since it is not gender sensitive. This work recommended that chemistry teachers must teach relevant mathematical concepts before teaching volumetric analysis and the method should be applied in any of the classes

Keywords: Achievement, Relevant Mathematical, Concepts Volumetric Analysis

Introduction
Chemistry, particularly volumetric analysis, is essential in STEM fields and practical applications, such as environmental science, pharmacology, and industrial chemistry (for example, synthesis and quality control). Yet, mastering the concepts in chemistry often presents significant challenges for students, particularly at secondary and tertiary levels (WAEC Chief Examiners Report, 2018; 2022). Recent studies emphasize the need for strong foundational knowledge in mathematics to aid understanding in chemistry (Fabriani and Ratna, 2024). Volumetric analysis, a core component in chemistry, involves techniques and calculations for determining the concentration of substances in solutions through titration. This process requires a solid understanding of mathematical concepts, such as ratios, proportions, and unit conversions, which often overlap with mathematics curriculum (Charles-Ogan *et al,* 2017). Despite its importance, studies have shown that students struggle with volumetric analysis due to its mathematical complexity. Volumetric analysis demands the application of mathematical principles, such as molarity calculations, stoichiometry, and dilution techniques. These calculations are often abstract, and students without a strong

mathematics foundation can find them confusing (Nejila *et al.,* 2023). Research has increasingly pointed to the role of mathematics in comprehension difficulties faced in chemistry. For instance, a study by Charles-Ogan, (2017) found that students lacking proficiency in algebra and ratio calculations often struggle to grasp chemical formulas and concentration calculations. Consequently, chemistry teachers are exploring ways to integrate relevant mathematical concepts within their teaching practices to improve comprehension and application skills in volumetric analysis.

To acquire volumetric analysis knowledge, one needs to understand the mathematical concepts that are relevant in the study of chemistry. Proper understanding of the mathematics concepts relevant in the study of volumetric analysis will enable us to acquire the necessary skills required in the application of chemistry knowledge in solving human problems or as may be required in the production, of fertilizers for Agriculture, production of drugs for treatment of sicknesses in human beings, among other

Mathematics according to Hornby (2020), the Oxford Advanced Learner's Dictionary of Current English can be defined as science of numbers, quantity and space. (Akanbi and Egbe 2016) sees mathematics as the study of quantities and relations through the use of numbers and symbols. Mathematics is described as the language of science (Gultepe *et. al.,* 2023). Thus, it is the foundation upon which the study of other sciences is based. Therefore, for excellence to be made in the study of other sciences, mathematics education should be given serious attention. The National Council of Teachers of Mathematics (NCTM, 2022) classified mathematics into Arithmetic, Algebra and geometry. Kanwal *et. al.,* (2022) maintained that mathematics is an indispensable tool in chemistry. Charlse-Ogan *et. al.,* (2017) asserted that sound and thorough understanding or knowledge of mathematical principles predetermine future success in disciplines like Chemistry, Physics and other Sciences and Technology related courses. He further observed that studies in mathematics and in all disciplines in which mathematics is used as a tool requires thorough knowledge of basic arithmetic operations, manipulation of algebraic symbols and understanding what that manipulation means. However, any student who is unable to perform arithmetic calculations and algebraic operations with reasonable speed and accuracy, and unable to understand which operations to use in solving a given problem and to interpret the result is handicapped. While evidence supports the value of mathematics integration in science education, there remains limited research on specific mathematics concepts most effective for enhancing understanding in volumetric analysis. Additionally, there is a need for longitudinal studies to assess long-term comprehension without gender biased.

Gender has been described as a cultural construct and social positions which members of the society attach to being male or female. Gender also means a dimension of social organization which shapes how people interact with others and how people behave or act and think about themselves. It also includes hierarchy and ranking of men and women distinctly in terms of power, wealth, privilege and other resources. Akinwumi and Falemu (2020) define gender as the social or cultural determinant that varies from place to place or culture to culture. It is not universal, unlike sex which is biologically determined and universal. Akani and Egbe, (2016) observed that throughout life (birth and death), human feelings, thought and actions reflect the social definitions that people attach to gender which affects the way the individual's daily activities may either be positively or negatively influenced. As gender affects the way people think of themselves, it teaches them to act in normative ways, that is acting and feeling in the manner that the society ascribed to each sex. Gender has been a serious variable that need to be consider in the educational research because of what society ascribed to gender. This work will also look at the influence of gender on the comprehension of volumetric after students have been taught relevant mathematics concepts Given the need for better

comprehension in volumetric analysis through targeted Mathematics instruction, this study aims to examine the effects of teaching relevant mathematical concepts on students' understanding of volumetric analysis.

Statement of Research Problem

Volumetric analysis, a core component of chemistry, requires an understanding of various mathematical concepts such as ratios, proportions, percentages, and molarity calculations (NCTM, 2022). However, many students struggle with these mathematical foundations, which directly impacts their comprehension and accuracy in volumetric analysis, a significant number of chemistry students have demonstrated difficulty in mastering this critical aspect of their studies (WAEC Chief Examiners" Report, 2022). Despite efforts by educators to improve comprehension through traditional chemistry instruction, the underlying mathematical deficiencies continue to hinder students' progress and confidence in performing volumetric analyses.

This study seeks to address whether teaching relevant mathematical concepts as a precursor to or integrated with volumetric analysis can enhance students' comprehension of volumetric analysis in chemistry. Hence the need to investigate the effects of teaching relevant mathematical concepts on chemistry students' achievement in volumetric analysis in Minna Education Zone, Niger State

Aim and Objectives of the Study

The aim of this study is to investigate the effects of relevant mathematics concepts prior knowledge on volumetric analysis in chemistry among secondary school students in Minna Educational Zone, Niger State. The following specific objectives are to be achieved:

1. Determine the effect of teaching relevant mathematical concepts for the comprehension of volumetric analysis on academic achievement of chemistry students achievement in Minna Education Zone
2. Determine influence of gender on the achievement of chemistry student taught relevant mathematical concepts in Minna Education Zone for the comprehension of volumetric analysis

Research Question of the Study

The following research questions were raised to guide the study:

1. What is the mean achievement scores of chemistry students taught relevant mathematical concept before teaching volumetric analysis and those taught volumetric analyses without learning relevant mathematical concepts?
2. What is the mean scores of male and female chemistry students taught relevant mathematical concepts before teaching volumetric analysis?

Research Null- Hypotheses

The following hypotheses are to be tested at 0.05 alpha level of significance

$H0_1$: There is no significant difference in the achievement of chemistry students taught relevant mathematical concepts before teaching volumetric analysis and those taught volumetric analyses with learning relevant mathematical concepts

$H0_2$: There is no significant difference between male and female in the academic achievement of chemistry students taught relevant mathematical concept before teaching relevant mathematical concepts

Methodology

The research design adopted for this research is a quasi-experimental research of pretest, posttest, non-randomized, non-equivalent control group. The experimental group was

exposed to teaching of relevant mathematical concepts before teaching of volumetric analysis while the control was taught volumetric analysis without teaching relevant mathematical concepts. The moderating variable which is gender varying at two levels (male and female). The effect of such on dependent variable (academic achievement of students in volumetric analysis) was also determined. Intact class was used for the research. The population of the study comprise all Chemistry students of 2023/2024 session in secondary schools in Minna Education Zone, Niger State, Nigeria. The target population for this study was two thousand Nine hundred and twenty-three (2,923) which comprised of 1,256 males and 1,256 females offering Chemistry in Minna Education Zone, Niger State. The choice of SSII is based on the fact that they are not preparing for Senior Secondary School Examination (SSCE) and the concept that was taught is contained in SSII syllabus and scheme of work.

The sample for this work was 349 chemistry students from Minna Education Zone. Minna Education Zone was clustered into two using cluster sampling techniques after this, purposive sampling technique was used to select six schools. These schools were purposely sampled based on equivalence (laboratories, facilities and manpower), gender composition (mixed schools that is male and female), and candidates' enrolment (enrolling students for SSSCE Chemistry examination for the minimum of ten years. Intact classes were used for the research. The test instrument that was used in collecting data for this study was researcher-developed Chemistry Achievement Test (CAT). The Chemistry Achievement Test (CAT) was consist of 60 multiple choice objectives items. The Chemistry Achievement Test (CAT) was based on SSII Chemistry curriculum on concepts of Volumetric analysis covered different level of understanding based on bloom's taxonomy of educational objectives (that is knowledge of facts, application of knowledge, interpretation of concept, comprehension, and analysis).

The students were expected to respond to the instrument in two sections. The first part (Section A) elicits information on achievement of the students in the contents. Section B of the CAT consist of 60 multiple choice questions. Each item of the instrument is a multiple-choice objective questions with five options (A-E) as possible answer to the question. Students were required to indicate the correct answer to the question, by shading on the box below the precise letter (A-E) that corresponds to the correct option for each item

Lesson Plan: The validation of lesson plan was done in two stages (i) content validation and (chemistry specialists)

Content Validation: The mathematical concepts were validated by two experts from department of mathematics and two mathematics teachers from secondary school in Minna Education Zone. The Chemistry contents of the lesson plan was validated by two Chemistry experts from Federal University of Technology Minna, and two Chemistry teachers from two secondary schools in Minna before the lesson plan was finally developed. The face validity in relation to the background of the students was considered. Subject matter content of the lesson plan was adequately and sufficiently covered the Nigerian secondary school Chemistry curriculum. after the lesson plan will be developed,

The Chemistry Achievement Test (CAT) CAT was given to two Chemistry education experts from Federal University of Technology Minna, Niger State, two senior Chemistry teachers from secondary schools. These assessed the face and content validity of the instrument. In addition, the experts were requested to critically examine all items in the test instrument with reference to the: appropriateness of the content, the extent to which the contents cover the topic they were meant to cover. Finally, comments, opinions and suggestions of the experts was used to make necessary amendment on the instrument.

The chemistry achievement test was pilot tested on 15 chemistry students from Minna Education Zone which is part of population but not sampled for the real experiment, the data gathered was subjected to Kuder Rechardson 21 (KR_{21}) and reliability of 0.78 was obtained. The CAT was administered to both experimental and control groups which serve as pretest, after this relevant mathematical concept were taught to experimental group before volumetric analysis were being taught and volumetric analysis was taught to control group without prior knowledge of relevant mathematical concepts, after the treatment CAT was administered as posttest. Data gathered was analyzed using descriptive and inferential statistics. Research questions were answered using mean and standard deviation and t-test was used to test the null hypotheses using SPSS version 22.00

Results and Discussion

Research Question One: What is the mean achievement scores of chemistry students taught relevant mathematical concept before teaching volumetric analysis and those taught volumetric analysis with learning relevant mathematical concepts

To answer this research question mean and standard deviation was calculated

Table 4. 1 Mean and Standard Deviation of Chemistry Students taught Volumetric after Relevant Mathematics Concepts and Those taught Volumetric Analysis without teaching Relevant Mathematical Concepts

Groups	N	Pretest Mean	Pretest Standard Deviation	Posttest Mean	Posttest Standard Deviation	Mean Gain
Experimental	191	14.62	6.75	61.69	13.45	47.07
Control	158	14.92	5.98	38.64	11.67	23.72

Table 4.1 shows the mean and standard deviation of pretest, posttest and mean gain scores of chemistry students taught relevant mathematical concepts before teaching volumetric analysis and those taught volumetric analysis without relevant mathematical concepts. The result revealed that chemistry students in experimental group had a mean score of 14.62, with standard deviation of of 6.72 at pretest and 61.69 as mean with 13.45 as standard deviation in the posttest. This gives the mean gain of 47.07 for chemistry students taught relevant mathematical concepts before learning volumetric analysis. Similarly, the result also reveals that control group, chemistry students taught volumetric analysis without prior knowledge of relevant mathematical concepts had 14.92as the mean score with 5.98 as standard deviation at pretest and 38.64 as the mean with the standard deviation of 11.67 at posttest. This gives the mean gain of 23.72 for chemistry students taught volumetric analysis without relevant mathematical concepts. It can be deduced that there is difference between the pretest and posttest mean scores which accounted for main gain scores for both experimental and control groups with experimental group having the higher mean gain score which shows that both group benefited from the teaching and learning exercises but experimental group benefited more

Research Question Two: What is the mean scores of male and female chemistry students taught relevant mathematical before teaching volumetric analysis

To answer this question mean and standard deviation were use in the results presented in Table 4.2

Table 4. 2: Mean and Standard Deviation of Male and Female Chemistry Students taught Volumetric after Relevant Mathematics Concepts before Volumetric Analysis

Groups	N	Pretest Mean	Pretest Standard Deviation	Posttest Mean	Posttest Standard Deviation	Mean Gain
Male	96	14.62	6.75	63.50	17.90	48.88
Female	95	14.62	6.75	61.64	17.48	47.02

Table 4.2 shows the mean and standard deviation of male and female chemistry students taught relevant mathematical concepts before volumetric analysis. The reveal that male chemistry students taught chemistry students taught relevant mathematical concepts before volumetric analysis has mean of 63.50 with standard deviation of 17.90 at posttest which gives a mean difference of 48.88 with standard deviation of 3.28 while female counterpart had the mean of 61.64 with standard deviation of 17,48 which gives the mean difference of 47.02 with standard deviation of 2.86. It can be deduced from the table 4.2 that both male and female chemistry students benefited maximally from the treatment

Hypothesis One: There is no significant difference in the achievement of chemistry students taught relevant mathematical concepts before teaching volumetric analysis and thosetaught volumetric analysis with learning relevant mathematical concepts
To test this formulated null hypothesis, analysis of independent t-test was carried out

Table 4.3: Independent t-test Analysis of chemistry students taught Relevant Mathematical Concepts Before Learning Volumetric Analysis and Those taught Volumetric Analysis without Prior Knowledge of Relevant Mathematical Concepts

S/N	Group	N	Mean	SD	Df	t-value	P-value
1	Experimental	191	61.69	14.27	347	4.235	0.00
2	Control	158	28.69	8.74			

Significant at 0.05 alpha levels

Table 4.3 shows that t-value= 4.235, df = 347, p <0.05 (0.00) The null hypothesis, which state that there is no significant difference in the achievement of chemistry students taught relevant mathematical concepts before learning volumetric analysis and those taught volumetric analysis without prior knowledge of relevant mathematical concept is hereby rejected

Hypothesis Two: There is no significant difference between male and female in the academic achievement of chemistry students taught relevant mathematical concept before teaching relevant mathematical concepts
To test this formulated null hypothesis, analysis of independent t-test was carried out

Table 4.4: Independent t-test of male and female chemistry students taught relevant mathematical concepts before learning volumetric analysis

S/N	Groups	N	Mean	STD	Df	t-value	P-value
1	Male	96	63.50	13.90	189	1.770	0.078
2	Female	95	61.78	14.48			

No significant difference (ns)

Table 4.4 reveal that t-value = 1.770, df = 189, p >0.05 (0.078) indicating no significant difference. The null hypothesis is accepted as stated. Therefore there is no significant difference in the mean achievement scores of male and female students taught relevant mathematical concept before learning volumetric analysis**.**

Discussion

Result from table 4.1 and 4.3 shows that experimental group has the higher mean gain than control group which shows that teaching relevant mathematical concepts is very necessary for easy comprehension of volumetric analysis moreover there was significant difference in the mean achievement scores of chemistry students taught relevant mathematics concepts before learning volumetric and those taught volumetric analyses without prior knowledge of mathematical concept. This finding concurred with findings of Febriani and Ratna, (2024) who say mathematical concepts must be taught before some topic should be taken in the chemistry classes. It also supports findings of Arokoyu and Le-Ere, (2019) finding out that mathematical concepts must be taught before must of the topics that require calculation in chemistry before teaching the topic itself for more comprehension of the topic

The male and female chemistry students taught relevant mathematical concepts before learning volumetric analysis performed equally which shows that both male and female students benefitted equally, this means that teaching relevant mathematical concepts before learning of volumetric analysis is gender friendly going by the mean and standard deviation of male and female chemistry students and the testing of null hypothesis which shows that there is no significant difference in the mean achievement scores of male and female chemistry students taught volumetric analysis after relevant mathematical have been taught. This finding support the findings of Kanwel *et. al.,* (2022) who found out that mathematics concepts are very important for the all the topic that involves calculation for better understanding of those topics

Conclusion

This research concluded that teaching relevant mathematical concepts before learning of volumetric analysis enhanced chemistry students' achievement

It was concluded that teaching relevant mathematical concepts is gender friendly because it enhanced both male and female academic achievement in volumetric analysis

Recommendations

1. Relevant mathematical concepts must be taught before learning of volumetric analysis in any chemistry teacher
2. Both male and female chemistry students must be exposed to relevant mathematical concepts before learning of volumetric analysis

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