`EFFECT OF EXPERIMENTATION ON CHEMISTRY STUDENTS' CONCEPTUALIZATION OF ACID, BASE AND SALTS

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Abstract
The study examined the effect of experimentation on chemistry students' conceptualization of acid, base, and salts in Bomadi Local Government Area of Delta State. Three research questions and their corresponding null hypotheses guided the study.A quasi-experimental pre-test, post-test non-equivalent control group design was employed. The population comprised 571 Senior Secondary I (SS1)Chemistry students in the eight public secondary schools in the study area. A sample of 101 students (46 male and 55 female) from two intact classes were selected using a simple random sampling technique. Data were collected using a 29-item multiple-choice validated Chemistry Achievement Test (CAT) with a reliability coefficient of 0.791. Mean statistics was used for answering the research question, while Analysis of Covariance (ANCOVA) was used for testing the hypotheses at 0.05 level of significance. Findings from the study showed there is significant difference in the mean achievement scores of students who were taught using experimentation method and those taught with lecture method; there is no significant difference in the mean achievement scores between male and female students taught using experimentation method; and there is no significant difference in the mean achievement scores between male and female students taught using lecture method. It was recommended among others that teachers should teach chemistry concepts using experimentation methods and students should exposed to the same instructional strategies irrespective of gender.

Keywords: Experimentation, Conceptualization, Gender difference and chemistry Students

Introduction

Chemistry, as a field of pure science, focuses on the study of the structure, characteristics, and applications of matter. This inquiry delves into the fundamental principles that govern the transformations experienced by matter. The field of chemistry holds significant importance in contemporary societies due to its essential role as a prerequisite for the pursuit of various science-oriented courses worldwide. Chemistry holds a significant position as a mandatory subject for university admission in Nigeria, particularly for students aspiring to pursue medical, engineering, pharmacy, computer science, and other science and technology-oriented fields. Therefore, it is evident that in order for a nation to advance in the field of science and technology, there is a need for enhancements in the instruction and acquisition of chemistry. Furthermore, it is imperative that performances in the field of chemistry, as well as in the broader realm of science, exhibit exceptional levels of proficiency. However, it appears that this

is not the situation in Nigeria as the academic achievements of students have not been promising.

Empirical evidence indicates that a significant number of secondary school students perceive chemistry as one of the most challenging scientific subjects to comprehend. According to Ihebuzor and Akpofure (2008), chemistry has a lower number of students compared to other science subjects, particularly at the tertiary level of Nigerian education, due to its perceived difficulty. Central to this challenge lies the issue of conceptualization pertaining to chemistry concepts that are imparted within the educational setting.

The term conceptualization takes its root from the word "concept". Urevbu (2017) sees concept as the meaning or meanings ascribed to a given symbolism. This symbolism could be a word, symbol, formulae, and mathematical symbol. Omoifo (2018) sees concept as an abstract idea based on phenomena. Conceptualization is the action or process of forming a concept or idea of something. A student can be said to have conceptualized if he/she can "effectively" relate a particular concept or concepts with other concepts within the same subject and even with other concepts outside the subject area and with the environment at large. Conceptualization is the link between teaching and performance. This also means that for every poor performance within a discipline there is a gap in the conceptualization process. This gap in conceptualization in the teaching and learning of chemistry can be filled with the introduction or inclusion of experimentation of chemistry concepts that are being taught in the classroom. The concept of acids, bases and salts is a major area in secondary school chemistry because over the years, it has formed the scope for which secondary school chemistry practical is centered and this also is seen in external examinations most notably West African Examination Council exams.

An experiment is a controlled test designed to prove a known fact, investigate the viability of a theory, or assess the effectiveness of an unproven claim. It is the process of carrying out a scientific method to ascertain something, particularly in a lab. The act of attempting new concepts, approaches, or pursuits; or a process used to confirm, deny, or validate a hypothesis is known as experimentation. According to Lunette and Hofstein (2007), experimentation is a type of learning where students interact with materials or secondary sources of knowledge in order to observe and comprehend the natural world. To put what you have learned into practice and apply concepts learned in the classroom to actual circumstances is known as experimentation. Exploratory learning and teaching methods include experimenting in the classroom. In most secondary schools and even in our higher education institutions, the terms "experimentation" and "practical" are used interchangeably. In the teaching and learning of chemistry across all educational levels, practical experiments hold paramount importance. It's arduous to conceive of studying or comprehending science devoid of hands-on experimentation or laboratory activities.

In external examinations, practical aspects of science subjected are written separately and they are scored. The grades or scores that students receive on internal or external exams represent their academic performance. The underperformance of secondary school students in Chemistry exams, both internal and external, is a cause for concern. WAEC Chief Examiner reports over the years, 2016, 2019, 2020, 2021 and 2022) have shown a downward trend in performance of students in chemistry and more specifically in titration that involves Acid, Bases, and Salts. WAEC Chief Examiner's report shows that most students act like strangers in the chemistry practical examination; not knowing what to do; where to stop or even what reagent or apparatus to use. Simply put, they act alienated during their practical chemistry examination. WAEC Chief Examiner's report 2016 also shows that most chemistry students lack appropriate knowledge of presentation of their reports during practical examination.

This WAEC Chief Examiner's report does not come as a surprise because even observation has revealed that most chemistry students cannot differentiate between a beaker and a conical flask. The ability to tell the difference between an acid and a base is the first step into

having a correct and accurate reaction and this cannot be effectively taught or comprehended by students without proper experimentation. Thus, concrete experimentation of the concept of Acids, Bases and Salts in senior secondary school would not only help to prepare and equip students for better performance in their S.S.C.E examination, it would also help to broaden their understanding of how and why different phenomena occur. Numerous authors, such as Etiubon, et al (2021), Esgueira (2019), Omotola (2018), and Achimugu (2016), have consistently associated the declining academic performance of senior secondary school students in science subjects, particularly Chemistry, with various factors. These factors include the leadership style of the principal, the quality of teachers, ineffective teaching methodologies employed by Chemistry educators, as well as deficiencies in infrastructure and instructional materials; factors at home; the lack of structured problem-solving techniques such as experimentation and faulty reasoning; the lack of preparation in mathematics; psychological factors; and government factors (human, material, financial, and physical resources). Amongst the above-mentioned factors, the lack of organized strategies like experimentation of chemistry concepts is one area of interest because of its role in the attainment of educational objectives and gender.

Student's gender may have an effect on their academic success. All classes and organizations of people around the world, particularly researchers and educators have been concerned about gender issues. The treatment of the gender issue depends on a number of factors, including social and cultural norms, lifestyle choices, and personal interests. In the colonial era, boys were permitted to go to school while girls stayed at home to take care of household chores. Some parents tell their daughters they are weird and might not be able to manage a married family, discouraging them from careers in science and technology. Some instructors and women believe that girls lack the intellectual capacity to compete with boys in demanding tasks involving mathematics and science.

The impact of gender inequality in school on students' achievement has been controversial. While some authors have argued that boys and girls accomplish at similar levels (Akpan, 2022; Adie, Obi, Okri and Ogbe, 2020), others contend that girls outperform boys in the classroom. However, other studies continue to hold the belief that the sex issue has little bearing on students' academic success. According to them, success depends on one's understanding and devotion. Different teaching strategies result in different outcomes, according to research, if the optimal outcome is to be reached, it is necessary to identify the optimum teaching technique for a particular group of students. Against this background this study, seeks to determine if experimentation method influences gender achievement of the concept of acids, bases and salts.

Objectives of the Study

The purpose of this study was to determine the effect of experimentation on students' conceptualization of acids, bases, and salts. Specifically, the study sought to:

1. Determine the difference in the mean achievement scores of students who were taught using experimentation method and those taught with lecture method.
2. Compare the difference in the mean achievement scores between male and female students taught using experimentation method.
3. Examine the difference in the mean achievement scores between male and female students taught using lecture method.

Research Questions

The following research questions were raised to guide the study.

i. What is the difference in the mean achievement scores of students who were taught using experimentation method and those taught with lecture method?
ii. What is the difference in the mean achievement scores between male and female students taught using experimentation method?

iii. What is the difference in the mean achievement scores between male and female students taught using lecture method?

Hypotheses

The following hypotheses were formulated and be tested at 0.05 level of significance.

Ho_1: There is no significant difference in the mean achievement scores of students who were taught using experimentation method and those taught with lecture method.

Ho_2: There is no significant difference in the mean achievement scores between male and female students taught using experimentation method.

Ho_3: There is no significant difference in the mean achievement scores between male and female students taught using lecture method.

Methodology

This study employed a quasi-experimental pre-test post-test non–equivalent control group design. The population of the study comprised all 571 senior secondary one (SS1) chemistry students in the eight public senior hugh schools in Bomadi Local Government Area of Delta State. Simple random technique was used to select two secondary schools from the population. The students in the two schools were used in their intact classes. The students were assigned into two groups. Group 1(Experimental) had 50 students (24 boys and 26 girls), while Group 2(control) had (22 boys and 29 girls), making a total sample for the study 101. The instrument used for data collection was a 30-item multiple choice "Chemistry Achievement Test – CAT", drawn from the concept of acids, bases, and salts. The CAT had five response options (A_E) with one correct answer and four distractors. the instrument consisted of section A and B. Section A elicited information on the students' personal data like name of school and gender, while section B contained themultiple-choice questions. The CAT was validated by three experts in Chemistry and Measurement/Evaluation to check for appropriateness of items and adequacy in measuring the objectives of the research. The instrument was pilot tested on thirty students in the population that were not part of the sample. Data obtained was analysed using Kuder Richardson Formula 20 and the reliability coefficient of 0.79 was obtained. Teachers from the sampled schools were trained as research assistants on the modalities of teaching the concept under consideration and the resource materials to be used for 2 days. Prior to the commencement of the treatment(teaching), a pre-test was administered to the students. The experimental group was taught the concept of acids, bases, salts using experimentation, while the control group was taught the same topics using lecture method. A reshuffled version of the pretest was administered after four weeks of teaching to the two groups as posttest. Data obtained were analyzed using mean, standard deviation, and Analysis of Covariance(ANCOVA) at 0.05 level of significance.

Results and Discussion

Research Question 1: What is the difference in the mean achievement scores of students who were taught using experimentation method and those taught with lecture method?

To answer the research questions, mean and standard deviation was used to analyze the data collected.

Table 1: Mean and Standard Deviation showing the mean achievement scores of students taught using experimentation method and lecture method (n = 101)

Teaching methods	n	Pretest		Posttest		Mean Difference
		Mean	SD	Mean	SD	
Experimentation	50	7.32	2.34	16.96	2.69	9.64
Lecture	51	7.63	2.42	12.26	2.37	4.63

The result in Table 1 reveals that the pretest–posttest mean score difference of 9.64 obtained by students taught using experimentation method was greater than that of 4.63 obtained by those taught using the lecture method. The pretest and posttest standard deviation scores of 2.34 and 2.69 as well as 2.42 and 4.63 obtained by the students taught with the experimentation method and lecture method respectively showed that, though the students taught using experimentation method had the highest mean score difference, the scattering of the raw score from the mean was slightly higher in the experimentation group. This means that students taught using experimentation method performed better than their counterparts taught with the lecture method.

To determine whether this difference was statistically significant, Analysis of Covariance (ANCOVA) was used to test H_{01}, and the result is shown in table 2.

$H0_1$: There is no significant difference in the mean achievement scores of students who were taught using experimentation method and those taught with lecture method

Table 2: Result of ANCOVA analysis of the difference in the mean achievement scores of students taught using experimentation method and those lecture method (n=101)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	571.06[a]	2	285.53	44.88	.00
Intercept	1666.36	1	1666.36	261.92	.00
Pretest	12.13	1	12.13	1.91	.17
Teaching methods	567.31	1	567.31	89.17	.00
Error	623.48	98	6.36		
Total	22677.00	101			
Corrected Total	1194.54	100			

The result in Table 2 shows the F-value of 89.17 and the corresponding probability level of significance of .00 alpha at 1 and 98 degrees of freedom. This level of significance is less than .05 in which the decision is based. With this result, the null hypothesis was rejected. This implies there is significant difference in the mean achievement scores of students who were taught using experimentation method and those taught with lecture method.

Research Question 2: What is the difference in the mean achievement scores between male and female students taught using experimentation method?

Table 3: Mean and Standard Deviation showing the difference in the mean achievement scores between male and female students taught using experimentation method (n=50)

Gender	n	Pretest		Posttest		Mean Difference
		Mean	SD	Mean	SD	
Male	24	7.29	2.69	17.38	2.39	10.09
Female	26	7.35	2.02	16.58	2.93	9.23

The result in Table 2 revealed that the pretest–posttest mean difference of male students taught using experimentation method was 10.09 while that of their female colleagues was 9.23. The pretest and posttest standard deviation scores of 2.69 and 2.39 as well as 2.02 and 2.93 obtained by the male and female students taught with the experimentation method respectively showed that, though the mean score for male students taught using experimentation method was slightly higher, the scattering of the raw score from the mean was slightly higher among female students.

To determine whether this difference was statistically significant, Analysis of Covariance (ANCOVA) was used to test H_{02}, and the result is shown in table 3.

$H0_2$: There is no significant difference in the mean achievement scores between male and female students taught using experimentation method

Table 3: Result of ANCOVA analysis of the difference in the mean achievement scores between male and female students taught using experimentation method (n=50)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.09[a]	2	6.55	.90	.41
Intercept	1162.17	1	1162.17	160.26	.00
Pretest	5.14	1	5.14	.71	.40
Gender	8.10	1	8.10	1.12	.30
Error	340.83	47	7.25		
Total	14736.00	50			
Corrected Total	353.92	49			

The result in Table 2 shows the F-value of 1.12 and the corresponding probability level of significance of .30 alpha at 1 and 47 degrees of freedom. This level of significance is greater than .05 in which the decision is based. With this result, the null hypothesis was retained. This implies there is no significant difference in the mean achievement scores between male and female students taught using experimentation method.

Research Question 3: What is the difference in the mean achievement scores between male and female students taught using lecture method?

Table 4: Mean and Standard Deviation showing the difference in the mean achievement scores between male and female students taught using lecture method (n=51)

Gender	n	Pretest		Posttest		Mean Difference
		Mean	SD	Mean	SD	
Male	22	8.05	2.61	12.23	2.41	4.18
Female	29	7.31	2.25	12.28	2.39	4.97

The result in Table 4 revealed that the pretest–posttest mean difference of male students taught using lecture method was 4.18 while that of their female colleagues was 4.97. The pretest and posttest standard deviation scores of 2.61 and 2.41 as well as 2.25 and 2.39 obtained by the male and female students taught with the lecture method respectively showed that, though the mean score for female students taught using lecture method was slightly higher, the scattering of the raw score from the mean was slightly higher among male students.

To determine whether this difference was statistically significant, Analysis of Covariance (ANCOVA) was used to test H_{02}, and the result is shown in table 4.

$H0_3$: There is no significant difference in the mean achievement scores between male and female students taught using lecture method

Table 4: Result of ANCOVA analysis of the difference in the mean achievement scores between male and female students taught using lecture method (n=51)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.54[a]	2	3.77	.66	.52
Intercept	534.23	1	534.23	93.54	.00
Pretest	7.51	1	7.51	1.32	.26
Gender	.35	1	.35	.06	.81
Error	274.14	48	5.71		
Total	7941.00	51			
Corrected Total	281.69	50			

The result in Table 4 shows the F-value of .06 and the corresponding probability level of significance of .81 alpha at 1 and 48 degrees of freedom. This level of significance is greater than .05 in which the decision is based. With this result, the null hypothesis was retained. This implies there is no significant difference in the mean achievement scores between male and female students taught using lecture method.

Discussion of the Results

The first finding of the study showed that there is significant difference in the mean achievement scores of students who were taught using experimentation method and those taught with lecture method. The finding could be attributed to the fact that when students are exposed to experimentation, the become actively involved in the process of teaching and learning and this help to concretize learning. The finding is in line with the observation of Lunette and Hofstein (2007), who reported that, in the teaching and learning of chemistry across all educational levels, practical experiments hold paramount importance. It is arduous to conceive of studying or comprehending science devoid of hands-on experimentation or laboratory activities.

The second findings of the study showed that there is no significant difference in the mean achievement scores between male and female students taught using experimentation method. This finding is in line with the findings of Ajayi and Ogbeba (2017) as well as Eze and Al-Mustapha who upholds the idea that gender has no bearing on chemistry achievement as it is supported by this study and also found no discernible difference in the interest of male and female students in science.

The third findings of the study showed that there is no significant difference in the mean achievement scores between male and female students taught using lecture method. This finding agrees with that of Ajayi and Ogbeba (2017) as well as Eze and Al-Mustapha who uphold the idea that gender has no effect on chemistry achievement and also found no discernible difference in the interest of male and female students in science.

Conclusion

Based on the findings of the study, it was concluded that experimentation enhance students' conceptualization of acids, bases, and salts in Bomadi Local Government Area of Delta State.

This also implies that the use of experimental activities for teaching chemistry helps in facilitating students understanding of chemistry content and enhance their academic achievement.

Recommendations

Based on the findings emanating from this study, the following recommendations were suggested:

1. Chemistry laboratory should be provided and should be well equipped by the Ministry of Education for effective teaching and learning of Chemistry concepts in Delta State Senior Secondary Schools.
2. Chemistry teachers should use experimentation in teaching Chemistry concepts in order to enhance students' achievement, interest and understanding in Chemistry.
3. All students should be encouraged to study sciences, irrespective of their gender.

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