Effects of Class Sizes on Senior Secondary School Students' Performance in Gas Laws in Dukku Local Government Area, Gombe State

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Abstract

The study examined the effects of class sizes on students' performance in gas laws. A quasi-experimental research design of a non-randomized and non-equivalent pre-test and post-test was adopted for the study. The population for the study comprised all five (5) public secondary schools located in Dukku Local Government Area of Gombe State, totaling 436 students. A purpose sampling technique was used to sample two intact classes of ninety-nine (99) students from the population. The Gas Law Performance Test instrument with 0.82 reliability coefficient was used for collecting data. The method of data analysis adopted by the study includes descriptive statistics and ANCOVA, which were used for answering the two research questions and testing the two null hypotheses at 0.05 level of significance. The findings indicated a statistically significant difference in the mean performance scores of the students taught gas laws in small class size and large class size, in favour of the small class size. Also, it was also discovered that class sizes have no effect on students' gender performance. However, the study recommended educators follow the National Policy on Education, emphasizing optimal student-teacher ratios for improved engagement, peer interaction, and academic performance.

Key Words: Class size, Gas Laws, and Performance

Introduction

Science education in Nigeria is pivotal for fostering economic growth, technological advancement, and societal transformation. The Federal Republic of Nigeria (FRN, 2013) underscores its significance in the National Policy on Education, which prioritizes the development of scientific literacy and critical thinking. According to Okebukola (2002), science education is a foundation for creativity and innovation, essential for industrialization and national development. Historical factors have also shaped the trajectory of science education in Nigeria, transitioning from colonial rote-based systems to post-independence reforms aimed at practical and relevant science curricula (Adesoji, 2008; Adeyemo, 2010).

Science is the systematic pursuit of knowledge, acquired through observation and experimentation (Ibezim, 2018). Meanwhile, science has always been recognized as the basic tool of industrialization and national development, and by implication, it brings economic and social happiness by providing employment and improving the welfare of the citizenry (Mieg, 2022). On the other hand, science education is a major field of practice that includes subjects such as biology, physics, and chemistry as the fundamental science subjects' perquisites for the senior secondary schools' curriculum in Nigeria (Titilayo, 2015).

Chemistry deals with the properties, composition, and structure of matter, the transformations they undergo, and the energy that is released or absorbed during these processes (SCUL, 2023). However, the study of gas laws is a pivotal branch within chemistry that explores the interrelation between pressure, volume, and temperature exhibited by gas samples, making it a cornerstone of senior secondary school chemistry education, typically introduced at the senior secondary school level. The Ideal Gas law is a culmination of fundamental Gas Laws such as Boyle's, Charles', and Avogadro's Laws. It is expressed by the equation $PV = nRT$, showcasing the connection between pressure (P), volume (V), number of moles (n), the Ideal gas constant (R), and temperature (T) in kelvins, applicable to any gas sample (Charles-Ogan, Gladys, Arokoyu & Amadi, 2017).

Chemistry has numerous applications in various ways, such as water purification, food and drug preparations, agricultural productions, and care resources management, varying materials for the construction of industries, roads, automobiles, and homes, in addition to solving problems resulting from human interaction with the environment (Banjoko, Gbadamosi, Abudu, Moyib, & Lawal, 2015). Moreover, chemistry education plays an important role in enhancing the quality of teaching and research as well as ensuring that students are equipped with good knowledge to produce intensive goods and services to meet human needs for food, health care products, and other materials aimed at improving the quality of life (Emendu, 2014).

Despite the importance of chemistry in personal and national development, students' performance in both internal and external examinations has been consistently poor (Eze & Okorie, 2019; Anyanime & Abasifreke, 2019; Aniodoh & Eze, 2022). Academic performance refers to a student's academic success at school, and it is measured in terms of a score or a percentage in test examinations or assignments (Ajayi, 2017). Several factors, including teacher qualifications, inadequate instructional materials, the abstract nature of chemistry concepts, gender disparities, absence of practical and mathematical skills, negative student attitudes, peer influence, lack of interest, teaching methods, and class sizes, have been implicated in students' poor performance in chemistry (Mushimiyimana, Renzaho, & Twizeyimana, 2020).

Class size is often mentioned by experts in the educational literature as having an effect on students' performance (Owoeye & Yara, 2011). The concept of class size, akin to a manager's 'span of control,' signifies the number of students for whom a teacher is primarily responsible throughout a school year; it operates as an educational metric describing the average number of students per class, necessitating a manageable number for effective teacher control, supervision, and instruction, as observed by Kenny (2020).

The National Policy on Education emphasizes the importance of specific student-teacher ratios at pre-primary, primary, and secondary levels to promote effective teaching and learning, specifying ratios of 1:25 for pre-primary classes, 1:35 for primary, and 1:40 for secondary schools (Jacob & Ndubuisi, 2020). Moreover, class size is often associated with increased teacher attention to individual student needs and reduced classroom disruptions, such as discipline issues. It is influenced by various factors, including subject matter, teacher allocation of time, student grouping, and instructional methods (Kasumi, 2014).

Meanwhile, class sizes based on student population can be divided into two categories: small class sizes and large class sizes (Wang & Calvano, 2022). Sparks (2010) observed that a class is considered large if it exceeds twenty-five students. In essence, according to Ajayi & Angura (2017), a large class is characterized by difficulties in teaching, managing, and assessing, presenting challenges and opportunities for both educators and learners, ultimately impeding a seamless teaching, and learning experience and prolonging the evaluation process. While a small class size fosters enhanced teacher-student engagement, peer interaction, and mutual support, minimizing focus on managing behavioral issues, as outlined by Blatchford (2017).

Moreover, small class size is widely supported by educators and parents as a measure that could enhance teaching quality, boost academic retention, and improve learning outcomes (Laitsch, Nguyen & Younghusband, 2021). Yara (2009) found out that the performance of students in large classes was very low (23%) compared to those students in smaller classes (64%). This is corroborated by Harold (1958) and Kolawole (1982) who observed that the relationship between class size and students' academic performance was negative such that the larger the size, the lower the level of students' performance, an assertion which agrees with Sitkei (1968) and Walberg (1969). Also, Krueger and Whitmore (2001) reported that smaller classes enhance student's performance.

Conversely, Pong and Pallas (2014) reported that students do better in large classes. This is supported by Omwirhiren and Anderson (2016), whose study revealed that large class size affects students' academic performance in chemistry. But, Owoeye and Yara (2011) argue that class size had no statistically significant effect on student performance. That is corroborated by Kenny (2020), who reported that chemistry classes, either small or large size, had no effects on students' academic performance and gender. Also, Filges, Sonne-Schmidt & Bjørn (2018) concluded that reducing class size from 40 or more to 20 students led to nearly no increase in students' performance.

Gender is a paramount factor when discussing the issues of students' performance in chemistry in relation to masculinity and femininity perceptions. The term gender is any physical and behavioral differences between males and females that are socially and culturally based (Szadvari, Ostatníkova & Durdiakova, 2023). Meanwhile, studies on gender differences in chemistry have continuously yielded inconsistent results as far as the students' performance in chemistry is concerned (Ajayi, Agamber & Angura, 2017; Oladejo, Nwaboku, Okebukola & Ademola, 2021; Ajayi & Ogbeba, 2017).

These reports are very disturbing as they pose a serious concern for the Government and other stakeholders in the field of education. If not checked, this may jeopardize the academic performance and placement chances of students in tertiary institutions, not only in chemistry education but also in other chemistry-related disciplines.

In recent times, His Excellency, Governor Muhammadu Inuwa Yahaya of Gombe State officially declared a state of emergency in the state's educational sector, citing deep dissatisfaction with

Gombe's 34th position in the 2019 West African Examinations Council (WAEC) ranking and expressing immediate action in response to this declaration. The governor expressed dismay over the consistent decline in the quality of basic education within the state, acknowledging Gombe's continual presence in the bottom 10 of both WAEC and NECO rankings. In a statement attributed to his media aide, Ismaila Uba Misilli, the governor conveyed his disappointment and concern, deeming it shameful and disheartening to witness such poor performance by students in national examinations (The Sun News Paper, 2019).

Additionally, in the 2019 WAEC, the overall percentage of students who achieved five credits or more, including mathematics and English, accounted for 31.07% of the total population of 15,078 students. Similarly, in the 2020 WAEC, the percentage of students obtaining five credits or more, inclusive of mathematics and English, decreased to 27.08%, reflecting a total population of 11,351 students (NBS, 2022).

However, chemistry is one of the subjects offered by the students in Gombe state who sat for the exams. Also, among the factors pinpointed in the course of discussing the students' performance, class sizes and gender variables are significant when it comes to the issues of students' performance in chemistry, most especially gas laws.

The questions now are: Could the effects of class sizes be responsible for the poor performance of students? What about the effect of class sizes on the students' gender performance? Therefore, this study intends to investigate the effects of class sizes on students' academic performance in chemistry with a particular emphasis on gas laws and gender.

Objectives of the Study

The study addressed the following objectives:

3. To determine the difference in the mean performance scores of students taught gas lawsin small class sizeand those taught in large class size.
4. To find the difference in the mean performance scores of male and female students taught gas laws in small class sizeand those taught in large class size.

Research Questions

The study addressed the following questions.

1. What is the difference in mean performance scores of students taught gas laws in small class sizeand those taught in large class size?
2. What is the difference in mean performance scores of male and female students taught gas laws in small class sizeand those taught in large class size?

1. **Hypotheses**

The study tested the following hypotheses at 0.05 levels of significance.

1. There is no significant difference in the mean performance scores of students taught gas laws in small class sizeand those taught in large class size.
2. There is no significant difference in the mean performance scores of male and female students taught gas laws in small class sizeand those taught in large class size.

Methodology

The quasi-experimental design of a non-randomized pre-test and post-test was adopted for the study. This design was preferably chosen because it helps to select samples for the small class size and large class size, which were divided into school A and school B of two intact classes respectively. The population for the study comprised all five (5) public secondary schools located in Dukku Local Government Area of Gombe State, totaling 436 students(Gombe State Ministry of Education: EMIS Unit, 2022).

A purposive sampling technique was used to sample two schools each of intact class from the list of five (5) public senior secondary schools in the Dukku Local Government Area of Gombe State. The sample size comprised a total of ninety-nine (99) students from two intact classes divided into a small size of 34 students (20males and 14females) and a large class size of 65 students (38 males and 27females) respectively. The choice of Senior Secondary one (1) Chemistry Students was appropriate for the study because the gas law is in their scheme of work.

The Gas Law Performance Test (GLPT) was used as an instrument for data collection and measuring students' performance in gas laws. The GLPT is thirty (30) items of compulsory multiple-choice questions numbered A, B, C, and D, carefully drawn from the standardized WAEC past question papers from 2010 to 2021, with each question carrying one (1) mark, making a total of 30 marks. This was done to ensure that the relevant items were included in the test and that each content area was given an adequate number of questions based on the behavioral objectives, Chemistry curriculum, and WAEC syllabus on the concept of gas laws: Boyle's Law, Charles' Law, and Avogadro's Law. The instrument was face and content validated by two experts, from the Test and Measurement Unit of the Department of Educational Foundations, and the Chemistry Unit of the Department of Science and Technology Education, University of Jos, Plateau State, Nigeria. Draft copies of the instrument, alongside the title, objectives, research questions, and hypotheses of this study were given to the experts. They made corrections, observations, and suggestions on how the items in the instrument addressed the study topic, the purpose of the study, the correctness and the scaling of the instrument, and proper wording (use of terms) for the instrument. The face and content validity ensured the relevance, appropriateness, and adequate coverage of the content area and objectives of the study. The corrections, observations, and suggestions made by these experts were incorporated to produce the final copy of the instruments. Also, the internal consistency of the research instrument was determined using the Pearson Product-Moment Coefficient (PPMC) and Spearman-Brown formula. This formula was applied to test the reliability of the instrument through a single administration of a pilot test conducted on a sample of 20 Senior Secondary Two students from Jos South Local Government Area of Plateau State, who were not part of the study area. The internal consistency of the instrument was determined, and an estimated reliability coefficient of 0.82 was obtained, demonstrating a high level of reliability.

Besides, lesson plans for the teaching of gas laws were written, and the schemes and records of work of the schools sampled for the study were rearranged among the Chemistry teachers prior to the start of the research in order to align the content of the subject for the purpose of the study. Additionally, a face-to-face method was used to administer the pre-test of the Gas Law Performance Test (GLPT) to the students. The pre-test questions were reshuffled and printed before they were used for the post-test.

The researcher and the research assistants taught gas laws to the small class size and large class for four weeks across three contacts at 40 minutes each. Thereafter, both the small class size and the large class size were post-tested. The pre-and post-test scripts for the students were collected, graded, and scored. The Statistical Package for Social Sciences (SPSS) version 26.0 was used to analyze the data from the pre-test and post-test statistically using descriptive statistics (mean, standard deviation). T-test and inferential statistics (Analysis of covariance, ANCOVA), with the hypotheses being tested at the 0.05 level of significance.

Results

Research Question One

What is the difference in mean performance scores of students taught gas laws in small class sizeand those taught in large class size?

Table 1: Mean Performance Scores of Students Taught Gas Laws in Small Class Size and Taught in Large Class Size

CLASS SIZES	*N*	PRETEST *Mean*	PRETEST *STDV.*	POSTTEST *Mean*	POSTTEST *STDV.*	*MEAN GAIN*
SMALL SIZE	34	10.47	2.69	43.65	5.90	**33.18**
LARGE SIZE	65	11.20	2.85	36.46	5.11	**25.26**

The data presented in Table 1 indicates that the small class size exhibited a pre-test mean of 10.47 (S. D= 2.69) and a post-test mean of 43.65 (S. D= 5.90), resulting in a mean gain of 33.18. Conversely, the large class size displayed a pre-test mean of 11.20 (S. D= 2.85) and a post-test mean of 36.64 (S. D= 5.11), yielding a mean gain of 25.26. Importantly, the small class size's mean gain of 33.18 surpassed the large class size's mean gain of 25.26, indicating a significant disparity in mean performance scores between the two classes in favor of the small class size.

An ANCOVA statistic was used to determine the statistical significance of the difference in mean performance scores between students taught gas laws in small and large class sizes.

Research Question Two

What is the difference in mean performance scores of male and female students taught gas laws in small class size and those taught in large class size?

Table 2: Mean Performance Scores of Male and Female students Taught Gas Laws in Small Class Size and Taught in Large Class Size

SMALL&LARGE SIZES	*N*	PRETEST *Mean*	PRETEST *STDV.*	POSTTEST *Mean*	POSTTEST *STDV.*	*MEAN GAIN*
MALES	58	10.67	2.92	38.19	6.12	**27.52**
FEMALES	41	11.34	2.61	39.98	6.64	**28.64**

Table 2 shows that the male gender had a pre-test mean of 10.67 (S.D = 2.92) and a post-test mean of 38.19 (S.D = 6.12), resulting in a mean gain of 27.54. On the other hand, the female gender displayed a pre-test mean of 11.34 (S.D = 2.61) and a post-test mean of 39.98 (S. D= 6.64), yielding a mean gain of 28.64. Notably, the mean gain of the female gender, 28.64, slightly exceeded the mean gain of the male gender, 27.54. Consequently, there exists a significant difference in mean performance scores between the male and female students taught gas laws in small class size and large class size, favoring the female gender.

To determine whether the difference between the mean performance scores of the Male and Female genders taught gas laws in small class size and large class size was statistically significant, an ANCOVA statistic was used to test hypothesis two.

Testing the hypotheses
Hypothesis One
There is no significant difference in the mean performance scores of students taught gas laws in small class size and those taught in large class size.

Table 3: Summary of ANCOVA for the Performance Scores of Students Taught Gas Laws in Small Class Size and in Large Class Size

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1174.453[a]	2	587.226	20.162	.000
Intercept	8779.676	1	8779.676	301.442	.000
CLASS SIZES	1174.276	1	1174.276	40.318	.000
PRETESTGLPT	21.866	1	21.866	.751	.388
Error	2796.052	96	29.126		
Total	154004.000	99			
Corrected Total	3970.505	98			

a. R Squared = .296 (Adjusted R Squared = .281)b. Computed using alpha = .05

The data presented in Table 4 shows that the ANCOVA result F (1, 96) = 40.318, p = .000, in which the value of p = .000< 0.05. Therefore, the null hypothesis that there is no significant difference in the mean performance scores of students taught gas laws in small class size and those taught in large class size is rejected. This implies a significant difference in mean performance scores between students taught gas laws in small and large class sizes.

Hypothesis Two.
There is no significant difference in the mean performance scores of male and female students taught gas laws in small class size and those taught in large class size.

Table 4: Summary of ANCOVA for the Performance Scores of Male and Female Students Taught Gas Laws in Small Class Size and in Large Class Size

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	76.999[a]	2	38.500	.949	.391
Intercept	9086.368	1	9086.368	224.038	.000
GENDER	76.823	1	76.823	1.894	.172
PRETESTGLPT	.384	1	.384	.009	.923
Error	3893.506	96	40.557		
Total	154004.000	99			
Corrected Total	3970.505	98			

a. R Squared = .019 (Adjusted R Squared = -.001) b. Computed using alpha = .05

The data presented in Table 4 shows that the ANCOVA result F (1, 96) = 1.894, p = .0172, in which the value of p = .0172> 0.05. Therefore, the null hypothesis that there is no significant difference in the mean performance scores of male and female students taught gas laws in small class size and those taught in large class size is accepted. This implies no significant difference in mean performance scores between male and female students taught gas laws in small and large class sizes.

Discussion

The result from testing hypothesis one shows that the students taught gas laws in small class size performed better than those taught in large class size. The significant difference in academic performance in gas laws favoured the class size and this suggested that small class size enhanced the students' performance in gas laws. This finding is in conformity with the study of Yara (2009) study which reported that the performance of students in large classes was very low (23%) compared to those students in smaller classes (64%). This finding is corroborated by Harold (1958) and Kolawole (1982), who observed a negative relationship between class size and students' academic achievement. Their studies revealed that as class size increases, students' achievement levels tend to decrease. This perspective is further supported by the works of Sitkei (1968) and Walberg (1969). Also, it is supported by Whitmore (2001) and Resnick (2008), who reported that smaller classes enhance student's performance. This also agrees with the findings of Keil and Partell (2018) who found that increasing class size has a negative effect on students' achievement, that is, it lowers students' performance at a decreasing rate.

However, the results of this finding disagree with that of Pong and Pallas (2014) who reported that students do better in large classes. Also, the finding disagrees with Owoeye and Yara (2011) who reported that class size had no statistically significant effect on student performance. Moreover, this study disagrees with that of Amoke (2020) who stated that chemistry classes either small or large size had no effects on students' academic performance and gender.

Besides, the result from testing hypothesis two shows that both male and female students achieved equality when they were taught gas laws in small class size and large class size. The insignificant difference in the academic performance of both genders in gas laws suggests that class sizes either large or small do not affect the students' gender achievement in chemistry. The finding of this study is supported by the study of by Amoke (2020) who reported that chemistry classes either small or large size had no effects on students' gender achievement in chemistry.

Conclusion

The study demonstrated a correlation between class sizes and students' academic performance, suggesting that larger classes result in lower performance, while smaller classes enhance student performance. However, there is no correlation between class sizes and students' gender-based academic achievement. In summary, the small class size enhanced the students' performance in gas laws than the large class size.

Recommendations

In view of the findings of the study, it was recommended that educators abide by the National Policy on Education which emphasizes the importance of specific student-teacher ratios enhance teacher-student engagement, students' interest, peer interaction, mutual support, and better academic performance.

The study on the correlation between class sizes and gender should be carried out in other science subjects in order to find-out if there is a relationship between them as well as their relevancy within the learning circle.

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