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EFFECTS OF GUIDED DISCOVERY APPROACH ON SENIOR SECONDARY TWO STUDENTS' PERFORMANCE IN VOLUMETRIC ANALYSIS IN GOMBE, GOMBE STATE

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ABSTRACT

This study investigated the effects of the Guided Discovery Approach on Senior Secondary Two (SS2) students' performance in volumetric analysis in Gombe, Gombe State. The study adopted a quasi-experimental research design using a non-randomized, non-equivalent pre-test and post-test control group arrangement. The population comprised 8,916 SS2 Chemistry students, consisting of 5,151 males and 3,765 females, from 18 public secondary schools. A sample of 98 students from two intact classes was selected through simple random sampling of schools. The instrument for data collection was the Volumetric Analysis Performance Test (VAPT), a researcher-developed instrument consisting of six structured performance questions with a total score of 25 marks. The instrument was validated by experts in Chemistry Education and Measurement and Evaluation, while its reliability was established using Cronbach's Alpha, yielding a coefficient of 0.85. Data collected were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at a 0.05 level of significance. The findings revealed that students taught using the Guided Discovery Approach performed significantly better than those taught using the conventional method, $F(1, 95) = 162.41$, $p < .001$. Furthermore, there was no significant difference between the performance of male and female students exposed to the Guided Discovery Approach, $F(1, 47) = 0.135$, $p > .05$. The study concluded that the Guided Discovery Approach improves students' performance in volumetric analysis and promotes equitable learning opportunities regardless of gender. It recommends the integration of guided discovery strategies in Chemistry classrooms, alongside teacher training and adequate laboratory resources.

Keywords: Guided Discovery, Volumetric Analysis, Chemistry Performance

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Introduction

Chemistry is an organized body of knowledge that employs systematic methods such as observation, experimentation, and logical reasoning to investigate natural phenomena (Ababio, 2024). It plays a fundamental role in national development, technological advancement, and societal well-being (Asaju & Ashepo, 2025). Chemistry, often described as the "central science," focuses on the composition, structure, properties, and transformations of matter and provides the foundation for understanding other scientific disciplines (Helmenstine, 2025). As a core component of science education, Chemistry occupies a central position in the secondary school curriculum in Nigeria due to its relevance to fields such as medicine, agriculture, engineering, and environmental sustainability (Shamsuddin, Arome, Aminu & Isah, 2017). Within the Nigerian educational system, the Chemistry curriculum has evolved over the years to address global scientific and technological demands. The curriculum emphasizes practical skills, scientific inquiry, and real-life applications through themes such as chemistry and industry, chemistry and the environment, and the chemistry of life. These curricular reforms are aimed at equipping students with the knowledge and skills required for national development and global competitiveness (Olubunmi & Aarinola, 2022). Furthermore, Chemistry serves as a prerequisite for many science-based careers, including medicine, pharmacy, engineering, and agricultural sciences, thereby highlighting its significance within the educational system (Olubunmi & Aarinola, 2022).

One of the major topics in the Chemistry curriculum is volumetric analysis, also known as titrimetric or quantitative analysis. Harris (2016) explains that volumetric analysis involves determining the concentration of a substance in solution through titration using a standard solution. It is a fundamental aspect of Chemistry that requires both conceptual understanding and practical competence, including accurate measurement, careful observation, and analytical reasoning (Skoog et al., 2014). The importance of volumetric analysis extends beyond the classroom, as it is extensively applied in industries such as pharmaceuticals, food production, petrochemicals, and environmental monitoring (Mendham et al., 2000). Despite its importance, students' performance in volumetric analysis at the secondary school level has remained consistently poor. Reports by the West African Examinations Council (WAEC, 2010–2019) have consistently highlighted students' inability to perform titration procedures accurately, frequent computational errors, and poor interpretation of experimental results. These persistent challenges indicate that students are not adequately acquiring the conceptual and procedural skills required for success in Chemistry. Academic performance in Chemistry refers to students' level of achievement as measured through tests, examinations, and practical assessments; therefore, poor performance reflects deficiencies in both the understanding and application of scientific concepts.

Several studies have identified specific difficulties experienced by students in volumetric analysis. Omwirhiren (2015) and Ezeudu et al. (2019) identified challenges such as poor understanding of titration principles, inability to handle laboratory apparatus correctly, weak mathematical skills, and difficulty in applying stoichiometric calculations. Students frequently experience difficulties with concepts such as mole ratios, concentration calculations, and endpoint detection, which often result in errors during both practical and theoretical tasks. Fatokun, Egya, and Uzoechi (2016) further observed that students tend to memorize procedures without understanding the underlying principles, leading to superficial learning. Similarly, Orimogunje (2018) noted that students perceive Chemistry as abstract and difficult, particularly when concepts are not connected with practical experiences. The persistent poor performance in

Chemistry has been attributed to several factors, including inadequate instructional materials, insufficiently trained teachers, overcrowded classrooms, negative student attitudes, and ineffective teaching methods (Ndritu, 2013; Ali et al., 2014; Sakiyo & Waziri, 2015). Among these factors, instructional strategy has been identified as a major determinant of students' academic achievement. Instructional strategies refer to the methods and techniques employed by teachers to facilitate effective learning (Teachers Institute, 2025). Conventional teaching methods, which are predominantly teacher-centered, often emphasize lectures, note-taking, and rote memorization. Although these approaches may facilitate content delivery, they do not sufficiently engage students or promote higher-order thinking skills (Amirova, 2025).

In contrast, learner-centered instructional strategies such as the Guided Discovery Approach have been widely advocated in science education. Ghafar (2024) emphasizes that guided discovery involves students actively participating in the learning process through exploration, experimentation, and drawing conclusions under the guidance of the teacher (Ubom et al., 2024). This approach is based on constructivist learning theory, which proposes that learners actively construct knowledge through experience and interaction (Lazonder & Harmsen, 2016). Guided discovery enhances critical thinking, problem-solving abilities, and deeper understanding of scientific concepts. Empirical studies have demonstrated its effectiveness in improving students' academic achievement in Chemistry. For instance, Wanbugu and Chungeiywo (2013) found that students taught using guided discovery performed better than those taught using conventional methods in practical Chemistry activities. Similarly, Sakiyo and Waziri (2015) reported improved performance and engagement among students exposed to activity-based instructional strategies, while Ndritu (2013) observed that guided discovery reduces misconceptions and enhances conceptual understanding. More recent studies further support these findings, indicating that inquiry-based approaches improve students' learning outcomes when appropriate scaffolding is provided (Furtak et al., 2012; Lazonder & Harmsen, 2016; Aina & Olanipekun, 2019). Importantly, several studies have examined the effects of instructional strategies on students' academic achievement. Lee and Boo (2022) reported that guided discovery produces higher achievement scores compared with conventional methods due to its emphasis on active learning and student engagement. Supporting this view, Udo and Etiubon (2011), Jack (2013), and Aina and Olanipekun (2019) found that students exposed to guided discovery retained concepts better and demonstrated superior performance compared with those taught using lecture methods. For example, Udo and Etiubon (2011) specifically reported improved retention, while Jack (2013) emphasized enhanced problem-solving abilities among students.

Another important variable in science education is gender. Gender refers to the social and cultural roles, behaviours, and expectations associated with males and females (Payne & Encyclopaedia Britannica Editors, 2026). Studies on gender differences in academic achievement in Chemistry have produced mixed findings, as observed by Oladejo et al. (2021). Some researchers, such as Ukozor (2011) and Awodun and Olarenwaju (2013), reported that male students outperform female students due to factors such as societal expectations, confidence levels, and classroom participation. However, other studies found no significant gender differences when effective instructional strategies are employed (Omwirhiren, 2015; Ezeudu et al., 2019). Furthermore, Ekenobi and Mumuni (2016), as well as Fatokun et al. (2016), indicated that both male and female students benefit equally from guided discovery approaches. Similarly, international reports by OECD (2015) and UNESCO (2017) emphasize that gender gaps in science achievement can be reduced through inclusive and student-centered teaching methods.

Achor and Kurumeh (2016) further explained that male students often outperform their female counterparts under conventional strategies due to greater classroom participation encouraged by teacher-centered practices, while Okeke (2014) observed lower achievement among female students under expository teaching methods. These findings align with Bamidele (2018), who noted that conventional teaching methods may unintentionally promote gender bias. Moreover, Bamidele and Adekola (2017) reported that the achievement gap widened over time in favour of guided discovery, while Akinbobola (2015) found a significant interaction effect between instructional strategy and academic achievement. Furthermore, Akanbi and Kolawole (2014) observed that conventional teaching methods may support short-term recall but are less effective in developing higher-order cognitive skills such as analysis and evaluation. In contrast, guided discovery significantly improves students' ability to solve complex problems and interpret experimental data (Ubom et al., 2024). This interaction effect indicates that the effectiveness of guided discovery becomes more evident when compared directly with conventional approaches that limit students' active involvement. In a related study, Olorundare and Omoniyi (2016) reported that students in guided discovery classrooms demonstrated significantly higher achievement and lower error rates in practical Chemistry tasks (Ekiugbo, 2024). Similarly, Ajayi and Olatunbosun (2018) found that guided discovery had a stronger positive influence on students with initially low achievement levels, whereas conventional methods tended to increase performance disparities. In contrast, conventional teaching methods have sometimes been found to favour male students because of their competitive and less interactive nature (Ukozor, 2011). This suggests that instructional strategy may moderate the relationship between gender and academic achievement. However, some studies provide contrasting evidence. Ibrahim (2019) reported no significant gender disparity when instructional delivery was standardized, while Adeyemi (2020) argued that factors such as teacher effectiveness and classroom management may play a more critical role than gender. Ezeudu and Obi (2013) therefore emphasized the need for pedagogical reforms that promote inclusive and equitable learning opportunities.

Despite the documented benefits of guided discovery, its implementation in Nigerian secondary schools remains limited. Ubom et al. (2024) attributed this limitation to factors such as large class sizes, inadequate laboratory facilities, and insufficient teacher training, while Orimogunje (2018) and Udo and Etiubon (2011) also highlighted the continued reliance on conventional teaching methods. Consequently, students continue to experience difficulties in mastering important Chemistry topics such as volumetric analysis. A critical review of existing literature reveals gaps, including inconsistencies in findings on gender, limited studies focusing specifically on volumetric analysis, and insufficient research conducted within Gombe Local Government Area. Therefore, the present study seeks to investigate the effects of the Guided Discovery Approach on students' performance in volumetric analysis and determine whether gender moderates these effects.

Research questions

1. What is the difference in the mean performance scores of students taught volumetric analysis using guided discovery and those taught using conventional methods?
2. What is the difference in the mean performance scores of male and female students taught volumetric analysis using guided discovery?

Hypotheses

1. There is no significant difference between the mean performance scores of students taught using guided discovery and those taught using conventional methods.

2. There is no significant difference between the mean performance scores of male and female students taught using guided discovery.

Methodology

The study employed a quasi-experimental research design using a non-randomized pre-test and post-test arrangement. Two intact classes were selected and assigned as the experimental and control groups. The population of the study consisted of 8,916 Senior Secondary Two (SS2) Chemistry students (5,151 males and 3,765 females) from 18 public secondary schools in Gombe Local Government Area. Through simple random sampling, two schools were selected, yielding a total sample of 98 students. The experimental group comprised 50 students (21 males and 29 females), while the control group consisted of 48 students (18 males and 30 females). SS2 students were selected because they had prior exposure to Chemistry concepts and the topic of volumetric analysis is included in their curriculum at this level. The study focused on acid-base titration, which is a major component of volumetric analysis. Students in the experimental group were taught using the Guided Discovery Approach, which involved problem-solving activities, estimation, measurement, and computational tasks, while students in the control group were taught using the conventional teaching method. Data were collected using the Volumetric Analysis Performance Test (VAPT), a researcher-developed instrument consisting of six structured essay questions with a total score of 25 marks. The instrument was validated by two experts in Chemistry Education and Measurement and Evaluation to establish content validity. The reliability of the instrument was determined using Cronbach's Alpha, which yielded a reliability coefficient of 0.85, indicating a high level of internal consistency and confirming the suitability of the instrument for the study. Pre-test assessments were administered to both groups before the commencement of instruction. The treatment lasted for four weeks, involving two 80-minute lessons per week. After the instructional period, a post-test was administered to determine the effect of the instructional approach on students' performance. Data collected were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at a 0.05 level of significance, controlling for initial differences between the groups. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 26. The study employed a quasi-experimental research design using a non-randomized pre-test and post-test arrangement. Two intact classes were selected and assigned as the experimental and control groups. The population of the study consisted of 8,916 Senior Secondary Two (SS2) Chemistry students (5,151 males and 3,765 females) from 18 public secondary schools in Gombe Local Government Area. Through simple random sampling, two schools were selected, yielding a total sample of 98 students. The experimental group comprised 50 students (21 males and 29 females), while the control group consisted of 48 students (18 males and 30 females). SS2 students were selected because they had prior exposure to Chemistry concepts and because volumetric analysis is included in their curriculum at this level. The study focused on acid-base titration, which is a major component of volumetric analysis. Students in the experimental group were taught using the Guided Discovery Approach, which involved problem-solving activities, estimation, measurement, and computational tasks, while students in the control group were taught using the conventional teaching method. Data were collected using the Volumetric Analysis Performance Test (VAPT), a researcher-developed instrument consisting of six structured essay questions with a total score of 25 marks. The instrument was validated by two experts in Chemistry Education and Measurement and Evaluation to establish its content validity. The reliability of the instrument was determined using Cronbach's Alpha, which yielded a reliability coefficient of

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Results

Research question 1: Comparison of performance between groups

Table 1: Mean Performance Scores of Students Taught with and Without Guided Discovery.

Group	N	Pre-test Mean	S.D	Post-test Mean	S.D	Mean Gain
Experimental	50	3.66	2.08	20.82	2.08	17.16
Control	48	5.00	2.02	14.25	2.08	9.25

The experimental group recorded a mean gain score of 17.16, while the control group recorded a mean gain score of 9.25. This indicates that students exposed to the Guided Discovery Approach achieved greater improvement in performance compared with students taught using the conventional teaching method.

Research question 2: Gender differences among students taught using Guided Discovery

Table 2: Mean Performance Scores by Gender

Gender	N	Pre-test Mean	S.D	Post-test Mean	S.D	Mean Gain
Male	21	2.10	1.30	21.43	1.96	19.33
Female	29	4.79	1.78	20.38	2.08	15.59

Both male and female students demonstrated improvement after exposure to the Guided Discovery Approach. Although male students recorded a slightly higher mean gain than female students, the difference was not sufficient to establish a meaningful gender disparity.

Hypotheses testing

Hypothesis 1

There is no significant difference in performance between students taught using guided discovery and those taught using conventional methods.

Table 3: ANCOVA for Performance Scores by Group

Source	Type III SS	Df	Mean Square	F	Sig.
Corrected Model	1058.306	2	529.153	92.208	.000
Intercept	5569.757	1	5569.757	970.567	.000
Pre-test	1.207	1	1.207	0.210	.648
Groups	931.999	1	931.999	162.407	.000
Error	545.173	95	5.739		

F (1, 95) =162.407, p = 0.000 < 0.05.

The ANCOVA result showed a significant difference between the two groups, F (1, 95) = 162.407, $p < 0.05$. Therefore, the null hypothesis was rejected. This indicates that students taught using the Guided Discovery Approach performed significantly better than those taught using the conventional teaching method.

Hypothesis 2

There is no significant difference in performance between male and female students taught using guided discovery.

Table 4: ANCOVA for Performance Scores by Gender

Source	Type III SS	Df	Mean Square	F	Sig.
Corrected Model	42.372	2	21.186	5.892	.005
Intercept	4345.648	1	4345.648	1208.499	.000
Pre-test	28.963	1	28.963	8.054	.007
Gender	0.486	1	0.486	0.135	.715
Error	169.008	47	3.596		

F (1, 47) = 0.135, $p = 0.715 > 0.05$.

The ANCOVA result indicated that gender had no significant effect on students' performance, F (1, 47) = 0.135, $p = 0.715 > 0.05$. Therefore, the null hypothesis was accepted. This implies that male and female students performed similarly when taught using the Guided Discovery Approach.

Discussion

The finding of this study showed that students taught using the guided discovery approach performed better than those taught using the conventional method. This result is in agreement with the findings of Wanbugu and Chungeiywo (2013), Sakiyo and Waziri (2015), and Ndritu (2013), who reported improved performance and engagement among students exposed to activity-based and learner-centered instructional strategies. Similarly, Udo and Etiubon (2011), Jack (2013), and Aina and Olanipekun (2019) found that guided discovery enhances retention and problem-solving ability. The present result also supports Lee and Boo (2022), who attributed improved performance to active learning and increased student participation. These areas of agreement suggest that guided discovery promotes deeper understanding and practical competence by involving students directly in the learning process. However, this finding contrasts with studies that emphasize the continued use of conventional teaching methods in many classrooms (Orimogunje, 2018; Ubom et al., 2024). While such studies did not necessarily report higher achievement with conventional methods, they highlight the persistence of teacher-centered practices due to constraints such as large class sizes and limited resources. The present study demonstrates that when guided discovery is effectively implemented, it can overcome some of these limitations and lead to better learning outcomes.

Regarding gender, the finding revealed that male and female students performed at comparable levels when taught using guided discovery. This result is consistent with the findings of Omwirhiren (2015), Ezeudu et al. (2019), Ekenobi and Mumuni (2016), and Fatokun et al. (2016), who reported that both male and female students benefit equally from learner-centered instructional approaches. It also aligns with international perspectives such as OECD (2015) and UNESCO (2017), which emphasize that inclusive teaching strategies can reduce gender gaps in science education. These agreements suggest that guided discovery provides equal learning opportunities by encouraging participation, collaboration, and active engagement among all

students. In contrast, the present finding disagrees with studies such as Ukozor (2011) and Awodun and Olarenwaju (2013), which reported higher performance among male students. Achor and Kurumeh (2016) also noted that male students tend to outperform females under conventional teaching methods due to greater classroom participation. The difference between these findings and the present study may be attributed to variations in instructional strategies. While earlier studies were largely conducted under teacher-centered conditions, the guided discovery approach used in this study promotes interaction and equal involvement, thereby reducing disparities. Furthermore, the findings of Ibrahim (2019) and Adeyemi (2020), which reported no gender difference under well-structured instruction, support the present result and suggest that instructional quality plays a more critical role than gender in determining students' performance.

Conclusion

Based on the findings of this study, it can be concluded that the guided discovery approach is more effective than the conventional teaching method in improving students' performance in volumetric analysis. Students who were exposed to guided discovery demonstrated higher performance and better understanding of concepts, indicating that active involvement in the learning process enhances both conceptual and practical competence in Chemistry. Furthermore, the study established that there was no difference in the performance of male and female students taught using the guided discovery approach. This implies that the strategy provides equal learning opportunities and supports inclusive classroom practices. The absence of gender disparity suggests that instructional strategy plays a more important role than gender in determining students' academic outcomes.

Recommendations

Based on the findings of the study, the following recommendations are made:

1. Chemistry teachers should adopt the Guided Discovery Approach in teaching volumetric analysis and other abstract Chemistry topics to enhance students' understanding and academic performance.
2. Educational authorities and curriculum planners should incorporate guided discovery strategies into the secondary school Chemistry curriculum to promote learner-centered teaching practices.
3. Teacher training institutions and professional development programmes should emphasize the use of guided discovery and other activity-based instructional strategies.
4. Schools should provide adequate laboratory facilities, equipment, and instructional materials to support effective implementation of guided discovery learning.
5. Teachers should encourage active student participation through experiments, problem-solving activities, and collaborative learning experiences.
6. Equal learning opportunities should be maintained in Chemistry classrooms to ensure that both male and female students actively participate in guided discovery activities.
7. Government agencies and stakeholders in education should organize workshops and seminars to train teachers on innovative instructional strategies in science education.

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