PEER-LED AND TEACHER-LED GUIDED INQUIRY TEACHING APPROACHES ON STUDENTS' ACADEMIC PERFORMANCE IN CHEMISTRY

Umanah, F. I. & Babayemi, J. O
Department of Science Education, Akwa Ibom State University
MkpatEnin, Nigeria.

Abstract
The study was carried out to examine the effect of peer-led and teacher-led guided inquiry teaching approaches on students' academic performance in Chemistry in Uyo Local Government Area. Three research questions and three hypotheses were formulated to guide the study. The design for the study was a quasi-experimental pretest-posttest design. The population for the study consisted of all the 2625 senior secondary two chemistry students in fifteen (15) public co-educational secondary schools in Uyo Local Government Area. A sample size of 97 SS 2 Chemistry students was used for the study. A simple random sampling technique was used in selecting two public co-educational secondary schools in the study area. In each selected school, one intact class of SS 2 Chemistry students was used for the study. The instrument used for data collection was the Chemistry Performance Test on Stoichiometry (CPTS). Two measurement and evaluation experts and a chemistry education lecturer subjected the instrument to face and content validation. A reliability coefficient of 0.85 was obtained using Kuder-Richardson formula-20 (KR-20). Mean and standard deviation were used to answer the research questions while Analysis of Covariance was used to test the hypotheses at a 0.05 level of significance. The findings showed that students taught the concept of stoichiometry using a peer-led guided inquiry teaching approach performed better than students taught using a teacher-led guided inquiry teaching approach. The finding also showed no significant difference in the mean performance scores between male and female students taught the concept of stoichiometry using peerled and teacher-led guided inquiry approaches. Based on the study's findings, it was concluded that the peer-led guided inquiry approach enhanced students' academic performance in Chemistry than the teacher-led guided inquiry approach in Uyo Local Government Area. It is recommended among others that a peer-led guided inquiry approach should be adopted by Chemistry teachers in the teaching and learning of stoichiometry and other Chemistry concepts.

Keywords: Peer-led guided inquiry, teacher-led guided inquiry, stoichiometry, academic performance and gender.

Introduction

In contemporary societies, science plays an increasingly pivotal role in both our professional endeavours and everyday lives. Educators, policymakers, and researchers are focusing on ensuring that science education continues to help prepare future citizens scientifically (Tytler, 2014). In this era of technological explosion and advancement driven by science and technology, the multi-dimensional impacts of science and technology on every facet of lives and our nation cannot be denied. Everyone, from the so-called little or poor man on the street to the very rich or highly placed individuals in the society is in one way or the other at ease with the importance of science (Owo, Idode&Ikwut., 2016).

Due to the significance and global influence of science, every nation strives to keep pace with advancements in scientific and technological development. Each nation endeavours to prioritize science education, aiming to equip its citizens with the essential skills and knowledge required for a capable workforce (Umanah& Udo, 2015). To achieve this requires effective teaching and learning of science at the secondary and tertiary levels of education. One of the major science subjects in the secondary school system in Nigeria is Chemistry.

Chemistry is the study of matter, its composition, properties as well as the various changes that matter undergoes. Chemistry is referred to as "the central science" and is needed as a prerequisite to the study of any science or technological-related discipline such as medicine, pharmacy, engineering and agriculture (Umanah& Sunday, 2022). It is relevant to several manufacturing industries such as pharmaceuticals, food processing, agriculture, clothing and textiles, cosmetics, petrochemicals as well as metallurgical industries (Gongden, 2016). The study of Chemistry equips the learners with knowledge, attitude and skills through which they understand the world and prepares them for the real world of work through career opportunities such as engineering, medicine, pharmacy, cosmetics and agriculture to mention just a few (Umanah& Sunday, 2022).

Despite the importance of Chemistry as the central science that forms the basic foundation for many science disciplines and in improving the quality of life, the performance of students in Chemistry in senior secondary schools has been poor in external examinations such as the West African Senior School Certificate Examination (WASSCE). The West African Examination Council Chief Examiners' reports (WAEC, 2019 -2022) confirm that students' performance in Chemistry has been below expectations over the years. The extent to which students fail in Chemistry raises significant inquiries about the teaching-learning process in Chemistry, although many factors have been attributed to the observed poor academic performance in the subject (Ojukwu, 2016; Ibezim, 2018; Umanah& Sunday, 2022).

Several researchers have reported that one of the reasons for poor performance is that Chemistry is perceived as an abstract and difficult subject by students and such topics considered by students as difficult are: stoichiometry, balancing of chemical equations, energy level and quanta; chemical reactions, chemical equilibrium, electrochemistry and thermodynamics (Otor, 2013; Ajayi &Ogbeba, 2017; Umanah& Sunday, 2022). Other researchers have attributed this poor performance to the instructional delivery approaches adopted by Chemistry teachers (Igboanugo& Njoku, 2015; Umanah& Udo, 2015; Ibezim, 2018; Umanah&Etiubon, 2022). In the opinion of Igboanugo and Njoku (2015) and Umanah and Etiubon (2022) a key determinant of student achievement is the quality of instructional methods and strategies employed by Chemistry teachers in teaching the subject. Goar, Buwah and Dukur (2021) asserted that teaching and learning have gone beyond the teacher standing in front of the learners to disseminate information to them without learners actively participating. Literature, however, is replete with evidence that chemistry classrooms are dominated by conventional methods of teaching which makes students passive recipients in the teaching/learning process. Giginna and Nweze (2014) have reported that inappropriate teaching methods have been adopted by chemistry teachers over the years. Uzoechi (2014) opined that science education (chemistry inclusive) must focus attention on innovative teaching methods that can promote creative thinking in science problem-solving. Science

educators also advocate a shift from teacher-centred methods to learner-centered methods that engage students actively in the process of learning. Effective and meaningful learning of Chemistry calls for a shift from a lecture-oriented classroom to a student-centred heads-on, hands-on and hearts-on activity-based classroom that stimulates the interest of the learners, gets them actively engaged in the learning process and facilitates conceptual understanding of the lesson (Umanah& Udo, 2015; Umanah&Etiubon, 2022). To improve students' academic performance in Chemistry and inculcate the desired scientific skills, it is essential to explore innovative instructional strategies that prepare them for potential intellectual challenges in an everchanging environment.

Chemistry, being an activity-oriented science subject should be taught using effective studentcentered and activity-driven teaching methods that emphasize the discovery of knowledge. It is therefore crucial at this period where significant importance is given to science education in general and Chemistry in particular as the bedrock of national development to explore effective methods of teaching Chemistry to enhance students' learning outcomes (Odukwe& Nwafor, 2022). Chemistry educators therefore should adopt student-centered and activity-oriented teaching approaches such as guided-inquiry teaching approaches to enhance maximum learning outcomes (Umanah& Udo, 2015).

Guided-inquiry teaching approach is an approach in which the students learn discrete science concepts and skills by following the teacher's scheduled instruction to learn a set of tasks that allows them to engage in hands-on activities (Abbey-Kallo, 2019). It is an approach in which students use processes to exhibit the mental and physical behaviours of scientists – scientific attitudes such as objectivity, creativity, experimentation, honesty and inquisitiveness. Through this approach, students are actively involved in the lesson, reducing the likelihood of merely presenting facts to them. Guided-inquiry teaching *approach* promotes critical thinking and problem-solving by guiding learners through a series of questions, investigations and reflections, fostering a deeper understanding of the subject matter and optimum better academic performance (Ekomaye, 2019).The question then is which of the guided-inquiry teaching approaches will prove more effective in facilitating students' academic performance in Chemistry considering their gender? Hence, the need for this study to investigate the effectiveness of teacher-led and peer-led guided-inquiry teaching strategies on students' academic performance on the concept of stoichiometry in Chemistry in Uyo Local Government Area.

Peer-led guided inquiry approach is a systematic, peer-mediated teaching. It involves students learning from each other in symbiotically beneficial modes involving the exchange of ideas, knowledge, experience and skills among peers who are equals in standing or matched companions (Ogunleye & Bamidele, 2013; Ali et al., 2020). In the peer-led teaching approach, students work together in groups to practice an activity or skill and provide each other with an immediate response (Ali, Adamu, Kuta &Tukura. 2020). By participating in discussions, students develop critical thinking and evaluative skills. Unlike rote learning, where learners just unquestioningly absorb the content, students here deduce viable conclusions collectively and independently from their instructors. Not only do students learn better but teachers also have their burden shared with the students (Pepe, 2021).

The teacher-led guided inquiry teaching approach is a teaching strategy that enables students to acquire knowledge on their own under the tutelage of a teacher. In teacher-led guided inquiry, the teacher

chooses the concept to be learn and goes further to guide the students to learn or investigate the concept. The teacher may start the lesson by posing a question or a problem to the students and thereafter guide them to arrive at the solution (Ekomaye, 2019). By so doing, the students are actively involved in the lesson thereby reducing the tendency of presenting facts to them. The goal of teacherled guided inquiry is to establish science process skills in the students and also enhance learning through students' active participation and investigation.

Gender is identified as one of the factors influencing student's academic performance at the secondary school level. Gender is a psychological term describing behaviour and attributes expected of individuals based on being male or female (Joseph et al., 2015; Umanah& Sunday, 2022). Researchers have reported that differences in performance exist between males and females and there have been several efforts to bridge this gap (Oladejo et al., 2021). Aniodoh and Egbo (2023) reported that female Chemistry students achieved higher than their male counterparts when taught the concept of qualitative analysis using the inquiry role instructional model.Some researchers have reported that male students perform academically better than their female counterparts in Chemistry (Gongden, 2016). Others found no significant difference between male and female chemistry students' academic performance (Umanah& Akpan, 2024; Umanah& Sunday, 2022;). With the contradictions on the influence of gender, this study therefore sought to further investigate the influence of gender on students' academic performance when taught the concept of stoichiometry using peer-led and teacherled guided inquiry teaching approaches.

Statement of the Problem

Despite the importance of Chemistry, the performance of students in Chemistry in secondary schools has consistently been poor in external examinations such as WAEC and NECO irrespective of the various teaching methods and strategies available for use by Chemistry teachers. The persistent poor performance has been attributed to factors such as poor teaching methods employed by chemistry teachers, the abstract nature of some Chemistry concepts, student attitude, poor problemsolving skills, and inadequate laboratory facilities among others. The West African Examinations Council (WAEC) Chief Examiners perennially report on students' weaknesses in chemical arithmetic, poor mathematical skills and inability to determine mole ratio from stoichiometric equations. Furthermore, researchers have reported that learners find stoichiometric calculations difficult due to misconceptions and lack of understanding of stoichiometry. Hence, there is a need for Chemistry teachers to adopt effective instructional approaches that will foster students' understanding of stoichiometry. The question then is, which of the guided inquiry teaching approaches will prove more effective in facilitating students' academic performance on the concept of stoichiometry considering their gender? The study therefore sought to investigate the effectiveness of peer-led and teacher-led guided inquiry teaching approaches on students' academic performance in Chemistry in Uyo Local Government Area.

Purpose of the Study

The main purpose of this study was to investigate the effect of peer-led and teacher-led guided inquiry approaches on students' academic performance in Chemistry in Uyo Local Government Area. Specifically, the study sought to:

i. Determine the difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.
ii. Determine the difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.

Research Questions

The following research questions were formulated to guide the study:

i. What is the difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry strategies?
ii. What is the difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches?

Hypotheses

The following hypotheses were formulated to guide the study:

i. There is no significant difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.
ii. There is no significant difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.

Methods

This study employed a quasi-experimental pretest posttest design which comprised one experimental group and one control group illustrated as follows:

E : O_1 x O_2

C : O_3 x O_4

Where E: experimental group (taught using peer-led guided inquiry)

C: Control group (taught using teacher-led guided inquiry)

O_1 and O_3 : pretest

O_2 and O_4 :posttest

The study was conducted in Uyo Local Government Area of Akwa Ibom State, Nigeria. The population of the study consisted of 2625 Senior Secondary School Two chemistry students in the fifteen (15) public co-educational secondary schools in Uyo Local Government Area. A sample of 97 Chemistry students from two public co-educational secondary schools was used for the study. A simple random sampling technique was used in selecting two (2) secondary schools out of 15 public co-educational

secondary schools in the study area. In each of the schools sampled, an intact class was used, one intact class was assigned to the experimental group and the other to the control group. The instrument used for data collection was the Chemistry Performance Test on Stoichiometry (CPTS). CPTS consisted of 20 multiple-choice questions with option A-D on the concept of stoichiometry. The instrument was validated by two measurement and evaluation experts and a Chemistry education lecturer in the Department of Science Education, Akwa Ibom State University. The reliability of the instrument was determined using a sample of 16 Senior Secondary Two (SS2) Chemistry students selected from a school in the study area but not part of the sample for the study. The scores obtained were analyzed using Kuder-Richardson Formula-20 and a reliability coefficient of 0.85 was obtained. The CPTS was administered to students as pretest and posttest. The lesson package for the experimental group was designed using a peer-led guided inquiry approach while the control group lesson package was based on a teacher-led guided inquiry approach. A pretest was administered to students in the two groups before treatment started. Students in experimental group were taught the concept of stoichiometry using peer-led guided inquiry approach while students in the control group were taught using teacher-led guided inquiry approach. The treatment lasted for two weeks after which the CPTS was reshuffled and administered as posttest to students in the two groups. Pretest and Posttest scripts from the two groups were collected, marked and recorded for data analysis. The research questions were answered using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses at a .05 level of significance.

Results

Research Question 1: What is the difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches?

Table 1: Mean and standard deviation of the difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches

Instructional approaches	N	Pretest		Posttest		Mean Difference
		Mean	SD	Mean	SD	
Peer-led	50	12.76	2.64	17.82	1.31	5.06
Teacher-led	47	13.09	2.97	15.89	2.32	2.80

The result in Table 1 indicated that the pretest–posttest mean difference in the performance scores of students taught the concept of stoichiometry using the peer-led guided inquiry approach was 5.06 while those taught with the teacher-led guided inquiry approach was 2.80. Also, the standard deviation scores for the two groups indicated that, although the mean score of the peer-led guided inquiry approach was higher, the scattering of the raw score from the mean was higher in the teacherledinquiry group. This

means that students taught the concept of stoichiometry using a peer-led guided inquiry approach performed better than those taught with the teacher-led guided inquiry approach.

Research Question 2: What is the difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches?

Table 2: Mean and standard deviation of the difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches

Instructional strategies	Gender	N	Pre-test		Post-test		Mean Difference
			Mean	SD	Mean	SD	
Peer-led	Male	26	13.04	2.49	17.65	1.20	0.93
	Female	24	12.46	2.81	18.00	1.41	
Teacher-led	Male	25	13.32	2.81	15.96	2.37	0.36
	Female	22	12.82	3.19	15.82	2.32	

The result in Table 2 showed that the pretest–posttest mean difference in the performance scores of male and female students taught the concept of stoichiometry using a peer-led guided inquiry approach was 0.93 while that of the male and female students taught with the teacher-led guided inquiry approach was 0.36. Also, the standard deviation scores indicated that, although the mean score of the female students taught with the peer-led guided inquiry approach was the highest, the scattering of the raw score from the mean was higher in the male students taught with the teacherled inquiry strategy. This result implies that there is a negligible difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.

Hypothesis 1: There is no significant difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.

Table 3: Result of ANCOVA analysis of the difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches

Source	Type III Sum of Squares	df	Mean Square	F-ratio	Sig.
Corrected Model	92.30[a]	2	46.15	13.17	.00

Intercept	1111.54	1	1111.54	317.14	.00
Pretest	2.39	1	2.39	.68	.41
Instructional approaches	91.32	1	91.32	26.05	.00
Error	329.46	94	3.51		
Total	28082.00	97			
Corrected Total	421.75	96			

*significant at .05 alpha level

The result in Table 3 showed an F-ratio of 26.05while the corresponding probability level of significance is .00 alpha at 1 and 94 degrees of freedom. This level of significance is less than .05 on which the decision is based. With this result, the null hypothesis was rejected. This implies there is a significant difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.

Hypothesis 2: There is no significant difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.

Table 4: Result of ANCOVA analysis of the difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches

Source	Type III Sum of Squares	df	Mean Square	F-ratio	Sig.
Corrected Model	94.25[a]	4	23.56	6.62	.00
Intercept	1098.80	1	1098.80	308.66	.00
Pretest	2.61	1	2.61	.73	.39
Instructional approaches	92.20	1	92.20	25.90	.00
Gender	.43	1	.43	.12	.73
Instructional approaches * Gender	1.47	1	1.47	.41	.52
Error	327.51	92	3.56		
Total	28082.00	97			
Corrected Total	421.75	96			

*significant at .05 alpha level

The result in Table 4 showed the F-ratio of 0.41while the corresponding probability level of significance is .52 alpha at 1 and 92 degrees of freedom. This level of significance is greater than .05 on which the decision is based. With this result, the null hypothesis was retained. This implies that there is no significant difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches.

Discussion

The result of the analysis of the difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches indicated that there is a significant difference in the mean performance scores of students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches. Hence, students taught the concept of stoichiometry using a peer-led guided inquiry approach had higher performance scores than their counterparts taught using a teacher-led guided inquiry approach. The finding lends credence to the observation of Ogunleye and Bamidele (2013) whose finding showed that the peer-led teaching approach is a form of active learning that demands students to engage in a sophisticated form of thinking. By participating in discussions, students develop critical thinking and evaluative skills. Like rote learning, where learners just unquestioningly absorb the content, students here deduce viable conclusions collectively and independently from their instructors. Not only do students learn better but teachers also have their burden shared. The finding is in line with that of Udoh and Obianuju (2019) who reported that students taught arithmetic progression using a peer-led team learning method performed better than students taught using a lecture method.

The result of the analysis of the difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches indicated that there is no significant difference in the mean performance scores of male and female students taught the concept of stoichiometry using peer-led and teacher-led guided inquiry approaches. The finding is in line with that of Udoh and Obianuju (2019) whose findings showed that male and female students taught arithmetic progression using peer-led team learning do not differ significantly in their academic performance. The finding is also in line with that of Umanah and Sunday (2022) whose finding indicated no significant difference in the mean performance scores of male and female students taught the concept of the periodic table using crossword puzzles and flashcards teaching strategies. The finding contradicts that of Parajuli and Thapa (2017) and Aniodoh and Egbo (2013) who found significant gender differences in the academic performance of students. The female students were found outperforming their male counterparts.

Conclusion

In conclusion, from the findings of the study, the peer-led guided inquiry approach improved students' academic performance than the teacher-led guided inquiry approach. Gender was not a determinant of students' academic performance. This implies that peer-led and teacher-led guided inquiry approaches enhanced both male and female students' academic performance when taught the concept of stoichiometry in chemistry.

Recommendations

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

1. Chemistry teachers should strive to use a peer-led guided inquiry approach in teaching Chemistry concepts as this will enhance learning and improve the academic performance of students.
2. Seminars, workshops and conferences should be organized by professional bodies like the Science Teachers Association of Nigeria (STAN) to create awareness on the use of studentscentred learning strategies such as the peer-led guided inquiry approach in teaching Chemistry and other science subjects
3. Pre-service teachers should be trained by tertiary institutions on how to design and use the peerled guided inquiry approach in teaching Chemistry and other science concepts.

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