EFFECT OF THINK-PAIR SHARE INSTRUCTIONAL STRATEGY ON SENIOR SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN KINETIC THEORY OF GASES IN CALABAR EDUCATION ZONE OF CROSS RIVER STATE

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Abstract

This study examed effect of think-pair-share instructional strategy on Senior Secondary School Students' Academic Achievement in Kinetic Theory of Gases in Calabar Education Zone of Cross River State.The design of the study was quasi-experimental, using retest-posttest non-equivalent control group design. The population of the study was males and females SS2 chemistry students in 22 public schools in Calabar Education Zone. The sample for the study was 120 senior secondary school year two chemistry students. The sample was obtained using multi-stage procedure. First, the coeducational schools were listed out according to their locations. Secondly, two coeducational schools were purposively selected. The purpose of selecting the schools was because they took care of the gender variable in the study and are situated far apart to avoid class interaction and subject contamination. From the two schools selected, the schools were randomly assigned to experimental and control groups. The experimental group school has 23 males 37 females while the control group school has 32 males and 28 females. The instrument for the study was Chemistry Achievement Test (CAT). CAT was made of 20 questions drawn from past WAEC questions on the concepts of Kinetic Theory of Gases. The reliability of the CAT was established using Kudder-Richardson 20 (KR-20).The hypotheses were tested at 0.05 alpha level using Analysis of Covariance (ANCOVA). The findings revealed that the mean academic achievement of students taught Kinetic Theory of Gases with think-pair-share strategies was significantly higher than that of students taught with lecture instructional strategy; Male and female students taught with think-pair-share strategy and lecture instructional strategy do not significantly differ in their mean academic achievement in Kinetic Theory of Gases when the effect of their pretest knowledge is removed; There was no interactive effect of treatment (think-pair-share and lecture instructional strategies) and gender on students' academic achievement in Kinetic Theory of Gases in the study area. Based on the findings of the study, it was recommended among others that; teachers should adopt the use of think-pair-share strategy to enhance students' academic achievement in Kinetic Theory of Gases; both male and female students should be exposed to think-pair-share strategy in learning chemistry concepts.

Introduction

Science is the foundation of technological advancements, and developing nations like Nigeria are working to advance scientifically. This has led to concerns about the effectiveness of science teaching in schools. Fundamental fields like biology, chemistry, physics, and mathematics are essential for exploring the universe and improving living conditions. Scientific investigation and construction of shelters are crucial for Earth's survival (Eze, 2019).

Chemistry is an important science subject and occupies a vital position in science education. According to Nnoli and Samuel (2023), chemistry is the study of the composition, properties, structures, interactions, and transformation of matter, either in isolation or combination. As a school subject, chemistry involves studying natural and artificially produced substances, their composition, their reactions and interactions, and their effects on humans and the environment. The effects of chemical reactions are observed daily, such as rusting kitchen utensils and individual allergic reactions to particular medicines Ani, Ani & Chukwuneke, 2015). Industrial chemical processes also lead to the production of substances like perfume and paint. Researchers like Nnoli (2022) and Chikendu (2022) have blamed the massive failure in Chemistry on ineffective teaching methods.

One of the concepts of Chemistry is kinetic theory of gases. The kinetic theory of gases attempts to explain the microscopic properties of a gas in terms of the motion of its molecules (Avadhut, 2013). The gas is assumed to consist of a large number of identical, discrete particles called molecules, a molecule being the smallest unit having the same chemical properties as the substance. Elements of kinetic theory were developed by Maxwell, Boltzmann and Clausius between 1860-1880's. Kinetic theories are available for gas, solid as well as liquid (Avadhut, 2013).

In spite of the significance of chemistry in the development of science, students' performance in the subject at the secondary school level has always been an issue in Nigeria. Reports from the West African Examination Council Chief Examiner for May/June Senior Secondary School Certificate Examination in Chemistry also indicate a persistent trend of students' poor performance over the years in SSCE (2021-2023).

Table 1: Chemistry students' academic Achievement in West African Examination Council (WAEC) from 2021-2023

Year	No of Students	Distinction (A1-B3)%	Credit (C4-C6)%	Fail (E7-F9)%
2021	6320	23.6	26.4	50.3
2022	6474	26.2	24.4	49.3
2023	6180	22.7	27.3	48.3

WAEC Chief Examiners' Report May/June 2021- 2023

Source: Department of Planning, Research and Statistics, Cross River State Ministry of Education

The WAEC Chief Examiner's report in 2023 highlighted the need for more effective teaching and learning of chemistry to ensure consistent improvement and sustenance of students' achievement in external examinations. The unpleasant trend in students' poor achievement in external examinations indicates that all is not well in Nigeria's educational system especially at the secondary level. Teachers needs to adopt diverse methods to engage students, arouse their interests, and engage them actively. Brooks and Brooks (2021) noted that the lecture method, which is teacher-centered, has its advantages, such as covering a large content area without much student achievement, however, this can lead to poor achievement and interest, especially in chemistry. To address this issue, Agba (2021) noted that a more reliable and effective methods of instruction to produce learner skills for a technologically and scientifically

dominated society. Teachers should be flexible, dynamic, thoughtful, and adaptable to change. Innovative teaching approaches, such as think-pair-share learning, offer an attempt at this goal.

Think-pair-share is a cooperative learning strategy that promotes individual student participation in discussing chemistry topics with peers. Eke (2021), is of the view that think-pair-share also called multi-mode discussion is a learning technique that provides processing time and builds in wait-time which enhances the depth and breadth of thinking. The general idea of think pair share technique is having the students independently think or solve a problem quietly, then pair up and share their thoughts or solution with someone else. In the think-pair-share classroom, every student is an active learner. According to Dange (2020), students remember 90% of what they hear, see, and practice cooperatively, enhancing their learning experience. Enyi (2022) noted that paired-taught students show higher academic achievement, persistence through graduation, and better reasoning and critical thinking skills and that they also have a deeper understanding of learned material, more time on task, and lower anxiety and stress levels. Pairing learning leads to greater intrinsic motivation, positive peer relationships, and higher self-esteem. Research on grouping and pairing in think-paired learning focuses on achievement levels, compatibility, assertiveness, speed, and gender (Katcha & Babagana, 2018). Proper implementation of think-pair-share learning could address educational system problems and increase students' interest in learning chemistry, potentially boosting academic achievement.

Creative teaching approaches can influence students' interests, and the researcher is optimistic that think-pair sharing will have the same effect on students' interest in chemistry, regardless of gender. Gender prejudice, a socio-cultural construct, is pervasive in Nigeria, particularly in the science classroom (Kolawole, 2019). Female students often believe chemistry is a male dominated subject, leading to low performance (Okeke, 2021). However, this is a false perception and requires a more personalized approach to science education. Research shows inconsistent evidence regarding students' academic achievement and interest in chemistry due to gender. Some studies suggest that males excel in competitive contexts, while females excel in partnered classroom settings (Kolawole, 2019; Adie, Inah, Ibu, Anditung, & Igyo, 2022.). He also added that Social competence, which refers to social behaviors and capacities, is also essential for effective engagement with others. Identifying a gender-paired learning technique that significantly boosts achievement for both genders is crucial for effective chemistry instruction. Therefore, gender was included as a moderating variable in this study, given the importance of chemistry as a science subject and its contribution to society.

Several researches have been carried out on the impact of think-pair-share instructional strategy on students' academic achievements. Achufusi, Okonkwo and Wisdom (2023) conducted a study to determine the effect of the think-pair-share instructional strategy on senior secondary school students' academic achievements and interest in chemistry. The study was guided by four research questions and six hypotheses. The study used a quasi-experimental research approach, notably the pretest-post-text design. The research was carried out in the Essien-udim Local Government Area of Akwa-Ibom State. The Essien-udim Local Government has ten (10) public senior secondary schools, with a total enrollment of 1018 SS2 chemistry students. The research sample size was 66 SS2 (34 males and 32 females) chemistry students drawn from two schools out of the ten (10) government secondary schools in the study area using the purposive sampling technique. The instruments used to collect data were a 50-item chemistry achievement test with multiple-choice questions and a 10-item chemistry interest scale with Lkert's response scale. The experimental group was taught using the think-pair-share strategy, while the control group was taught using the lecture method. To answer the study questions, the mean and standard deviation were used, and ANCOVA was used to test the null hypotheses at the 0.05 level of significance. The findings show that students taught using the think-pair-share strategy performed better and had a higher interest in chemistry than those taught using the lecture method. There was no interaction effect of gender and method of

instruction on students' academic achievement, as well as on academic interest of student in chemistry.

Omeje (2024) study investigated the effect of think-pair share instructional strategy on senior secondary school students' academic achievement in acid-base reactions in Enugu Education zone of Enugu State. Two research questions guided the study while three null hypotheses were tested at .05 level of significance. Quasi experimental research design was adopted for the study. The population for the study comprised 3,142 Senior Secondary School II (SS II) chemistry students. The sample size of 326 SS II students was drawn using purposive random sampling technique. The instrument for data collection was Acid-Base Reactions Achievement Test (ABRAT) which was developed by the researcher and validated by three experts. Kuder Richardson 20 (K-20) formulas were used to estimate the reliability of the instrument and a reliability index of .80 was obtained. Mean and standard deviation were used for answering the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses. The findings of the study showed that students who were taught acid-base reactions using think-pair share instructional strategy had improved academic achievement than their counterparts who were taught using lecture method. It was also found that male students had improved academic achievement than their female counterparts when exposed to think-pair share instructional strategy.

Arokoyu and Nwafor (2019)., Adie, Obi, Okri, and Ogbe, (2020) study investigated video-based think-pair-share instructional strategy on secondary Chemistry school students' performance on periodic table in PHALGA. Influence of gender on Chemistry students' performance was considered. Two objectives, two research questions cum hypotheses were tested. Quasi-experimental was employed in this study. One hundred and three (103) Chemistry students from two mixed secondary schools randomly selected participated in the study. Video-based instructional package on periodic table as a concept in Chemistry was used as the treatment while Periodic Table Performance Test (PTPT) was utilized to gather data. Mean and Standard deviation helped in answering the research question. ANCOVA tested the hypotheses. The findings of the study revealed that significant difference existed between the academic performance of students in experimental and control groups. In addition, gender had no influence on Chemistry students' performance in think-pair-share group.

Nnoli (2024) conducted a study to investigate the impact of the Think-Pair-Share (TPS) strategy on students' academic performance in Chemistry at the Awka Education Zone, establishing its significance in addressing persistent poor performance in the subject. A quasi-experimental design was employed, with Chemistry taught to the experimental group via TPS and to the control group by traditional lecture methods. The study's population consisted of all Chemistry students in public secondary schools within the Awka Education Zone, totaling 1,298 students, from which a sample of 120 students (60 males and 60 females) was drawn using purposive sampling and straightforward balloting. Data were collected using the Achievement in Chemistry Test, a validated instrument with a reliability factor of 0.83. Mean and standard deviation were used to analyze the research questions, while a t-test was used to examine the hypotheses. Results showed that students taught Chemistry using TPS outperformed those taught by lecture. Male students taught using TPS outperformed female students, whereas, with the lecture method, male students also outperformed female students. There was a significant difference in achievement scores between students taught with TPS and those taught with the lecture method, as well as between Male and Female Students taught with TPS.

Usang and Okoli (2021) conducted a study to investigate the effect of think-pair-share strategy on secondary school students' academic achievement in chemistry. Two research questions guided the study and six hypotheses were tested at 0.05 level of significance. The quasi-experimental design was adopted for the study. The population of the study was 2, 345 senior secondary school year two (SS2) chemistry students in Abi local government area of

Cross River state out of which a sample of 121 students obtained using purposive and random sampling was involved in the study. The instruments for data collection was Chemistry Achievement Test (CAT) validated by two three experts. The reliability of the instruments were established using Kuder-Richardson Formula 20 for CAT to be 0.63. Data were collected by administering the instruments as pretest and posttest before and after treatment respectively. The data obtained were analyzed using mean, standard deviation and analysis of covariance. The findings of the study revealed that there was significant difference in the mean academic achievement scores of the students taught using think-pair-share and those taught using conventional method in favour of think-pair share strategy. I

Edem, Nyakno and Assan (2023) conducted a study to investigate the influence of think pair share instructional strategy on Senior Secondary School Students Academic Performance and Retention in Science Subject in Akwa Ibom North East Senatorial District. The study adopted a Quasi Experimental Design. Six research question and six hypotheses were formulated to guide the study and eleven thousand, seven hundred (11,700) SSII students in Akwa Ibom State. Chemistry Achievement Test (CAT) and chemistry retention test (CRT) were developed by the researcher and used for data collection. Data collected were analyzed using mean, standard deviation and analysis of covariance (ANCOVA). The findings of the study were that there was a significant difference between the mean achievement scores of chemistry students taught in the class using think pair strategy and those taught using lecture method and there was no significant interacting effect of gender and teaching methods on students mean Achievement in science subject.

Obikezie, Ezeliorah and Okafor (2023) conducted a study to investigate the effect of generative learning model on secondary school students' academic achievement in Chemistry. It covered the topics of kinetic theory of gases and gas laws. Two research questions and two hypotheses were used to guide the study, relevant literature were also reviewed. The study was carried out in Awka Education zone in Anambra State. The population of the study consists of eight thousand five hundred and eighty three SS1 Chemistry students in the zone. The sample size for the study comprised of one hundred and eighty three (73 males and 110 females) SS1 Chemistry students. The study adopted quasi-experimental design. Out of 49 co-educational secondary schools in the zone, four co-educational schools were selected. Two were assigned to experimental group which used GLM instructional strategy while two were assigned to control group which used demonstration instructional strategy DIS. 35 male and 67 female Chemistry students were assigned to experimental group which received treatment involving teaching Chemistry using generative learning model instructional strategy GLM while 38 male and 43 female Chemistry students were assigned to control group which were taught using demonstration instructional strategy DIS. Twenty- five Chemistry achievement test (CAT). The instruments were validated by experts in science education department and education foundation. CAT reliability was established using Kudar Richardson 20 (KR-20) which yielded reliability coefficient of .87. Mean and standard deviation were used to answer the research questions while analysis of covariance (ANCOVA) was used to test the hypotheses at .05 level of significance. The findings of the study revealed that, though generative learning model improve students' academic achievement of secondary school students taught Chemistry with demonstration instructional strategy in control group, DIS significantly achieved better than those taught with generative learning model in experimental group. Also the study revealed that, there is no significant difference in male and female academic achievement in Chemistry. Based on the findings of the study, it was concluded that the use of generative learning model instructional strategy improves academic achievement of Chemistry students not minding the gender.

Bamiro (2015) conducted a study to investigate the effects of three strategies (i.e., guided discovery, think-pair-share, and lecture) on senior secondary school students' achievement in

chemistry. A pretest, posttest, control group quasi-experimental design with a 3 × 3 × 2 factorial matrix was adopted for the study. Treatment was at three levels (guided discovery, think-pair share, and lecture strategies). Intervening variables were cognitive entry behavior at three levels (high, middle, and low) and gender at two levels (male and female). Two hundred forty-two Senior Secondary 1 students in intact classes from six secondary schools in Ijebu Ode and Odogbolu Local Government Areas of Ogun State were randomly assigned to the treatment and control groups. Three instruments were developed and used to collect data from students during the 8-week treatment program. The data collected were subjected to analysis of covariance and multiple classification analysis. Scheffé test was further used as post-hoc measures. Where significant interactions were observed, they were represented with graphical illustrations. It was found that students taught with guided discovery and think-pair-share strategies obtained significantly higher posttest mean scores than those in the lecture strategy, $F(4, 223) = 51.66$, $p < .05$. The use of guided discovery and think-pair-share strategies had great potential for improving achievement in chemistry and science learning generally.

Ribhi and Ahmad (2017) carried out a study to examine the impact of Think – Pair – Share strategy on the achievement of third grade student in sciences in the educational district of Irbid, it was used the semi experimental in this study, the sample of study consisted of (120) students of third grade student in the educational district of Irbid, They were distributed into two groups: the control group which consisted of (30) male students and (30) female students; and the experimental group which consisted of (30) male students and (30) female students, the findings of the study show that there are statistically differences in grades of students due to group variable at the significance level (0.05), and the differences were in favor of the experimental group and there are statistically differences due to gender at the significance level (0.05) in favor of females. The study recommended to entry (Think – Pair – Share) strategy within the teaching strategies used by students during the teaching and the involvement of teachers in training courses on (Think – Pair – Share) strategy.

An examination of gender disparities in the context of technological proficiency revealed a nuanced relationship between perceived and actual online skills. The literature on gender disparities in technology engagement presents a complex picture, with findings indicating both differences and similarities in how men and women interact with digital tools. Odagboyi (2015) carried out a study to examine the effect of gender on the achievement of students in biology using the jigsaw method. The sample was made up of 87 students in SS1 in a secondary school. The study utilized an intact class because the study took place in a normal school term. There were 39 males and 49 females. The Biology Achievement Test (BAT) was constructed from past WAEC questions. These questions are standardized test and so were not subjected to further reliability test. The students administered the BAT as pretest, and the results were collated by gender. A t- test analysis showed that there was no significant difference between the mean scores of boys and girls. The class was taught, topics in microorganisms for 12 weeks. At the end of the 12 weeks, the BAT was administered as posttest. The results were analyzed using the t-test at 0.05 level of significance. Results showed that there was a significant difference between the mean scores in favour of the males. This showed that the males gained more from the jigsaw method compared with the females.

Adigun et al (2015) conducted a study to examine the relationship between student's gender and academic performance in computer science in New Bussa, Borgu local government of Niger State. Questionnaire which consist of 30 multiple-choice items drawn from Senior School Certificate Examination past questions as set by the West Africa Examination Council in 2014 multiple choice past question was used as the research instrument consist. The questionnaire was administered to 275 students from both private and public schools in the study area. The students' responses were marked and scored, afterward analyzed using independent t-test. The results of the study showed that even though the male students had slightly better

performance compared to the female students, it was not significant. This better performance was found to be pronounced in the private school which was shown to possess the best male brains found in the study area.

Statement of the Problem

The underachievement of Chemistry students especially in the Kinetic Theory of Gases is evident in Nigerian schools. It is public knowledge that the students' poor academic achievement in our schools has diminished the mean achievement expectations. This is visible in various examination outcomes as stated earlier. This has been the concern to various stakeholders in the educational industry, policy makers, the ministry of education, teachers and even parents.

Various steps had been taken by the government at all levels and educational planners in Nigeria, to solve the issue of students' poor performance in biology. For instance, the government has strengthened its policy on school supervision to make teachers more committed and dedicated to duty, encouraged science teachers through science teachers' allowances, rural teacher's allowances and sponsorship at seminars and grants of in-service courses. Also, there has been consistent increase in annual allocation to education as revealed by the federal Government. Furthermore, the Cross River State government has renovated most schools across the state and equipped their laboratories. Also, there has been increase in teaching period for science subjects (Chemistry inclusive) in all government schools from 3 periods to 5 periods a week.

The disparity in academic performance between male and female chemistry students in Cross River State, Nigeria, is a persistent concern. Despite efforts to promote gender equality in science education, males continue to outperform females in chemistry examinations. This issue is particularly pronounced in rural areas, where limited resources and inadequate teaching methods exacerbate the problem.

While innovative teaching methods like Think-Pair-Share and Reciprocal Peer Tutoring have shown promise in improving student understanding of complex concepts like Kinetic Theory of Gases, the effectiveness of these methods in bridging the gender gap in chemistry education remains unclear. Hence, this study sought to investigate the effect of think-pair-share instructional strategy on Senior Secondary School Students' Academic Achievement in Kinetic Theory of Gases in Calabar Education Zone of Cross River State.

Purpose of the Study

The purpose of the study was to investigate the effect of think-pair-share instructionalstrategy on Senior Secondary School Students' Academic Achievement in Kinetic Theory of Gases in Calabar Education Zone of Cross River State. Specifically, the study sought to find out the:

1. difference in the mean achievement scores of students taught Kinetic Theory of Gases with think-pair-share strategy and those taught with lecture strategy.
2. difference in the mean achievement scores of male and female students taught Kinetic Theory of Gases with think-pair-share strategy
3. interaction effects of teaching methods and gender on students' achievement in Kinetic Theory of Gases.

Statement of hypotheses

The following hypotheses were tested at 0.05 level of significance:

1. There is no significant difference in the mean achievement scores of students taught Kinetic Theory of Gases with think-pair-share strategy and those taught with lecture strategy.

2. There is no significant difference in the mean achievement scores of male and female students taught chemistry with think-pair-share strategy.
3. There is no significant interaction effect of teaching methods and gender on students' achievement in Kinetic Theory of Gases.

Methodology

The design of the study is quasi-experimental, specifically the pretest-posttest non-equivalent control group design. The area of the study was Calabar Education Zone of Cross River State. The population of the study was 2, 345 (1,532 males, 813 females) SS2 chemistry students in 22 public schools in Calabar Education Zone.

The sample for the study was 120 senior secondary school year two chemistry students. The sample was obtained using multi-stage procedure. First, the coeducational schools were listed out according to their locations. Secondly, two coeducational schools were purposively selected. The purpose of selecting the schools was because they took care of the gender variable in the study and are situated far apart to avoid class interaction and subject contamination. From the two schools selected, the schools were randomly assigned to experimental and control groups. The experimental group school has 23 males 37 females while the control group school has 32 males and 28 females.

The instrument for the study was Chemistry Achievement Test (CAT). CAT was made of 20 questions drawn from past WAEC questions on the concepts of Kinetic Theory of Gases. The answer options are lettered A-D. To ensure adequacy of questions in the content areas taught, a table of specification was used to determine the number of question in the low and high order cognitions. Also, lesson plans were prepared on the concepts of Kinetic Theory of Gases for the treatment group using think-pair-share strategy. The control group lesson plan was on lecture method of teaching.

The instrument was validated by lecturers in the Departments of Science Education and Educational Foundations. The reliability of the CAT was established using Kudder-Richardson 20 (KR-20). CAT was administered once to forty SS2 chemistry students in a school outside the area of study and the data generated was used to computer the internal consistency which yielded 0.72.

The instruments were administered as pretest and posttest. The data generated from the tests were organized and analyzed. The analysis was based on the hypotheses. The hypotheses were tested at 0.05 alpha level using Analysis of Covariance (ANCOVA). The decision rule is that when P-value was less than or equal to 0.05, the null hypotheses was rejected and whenever P-value is greater than 0.05, the null hypotheses was not be rejected.

Results

Test of hypotheses

All the hypotheses were tested at .05 significance level.

Hypothesis 1

There is no significant difference in the mean achievement scores of students taught Kinetic Theory of Gases with think-pair-share strategy and those taught with lecture strategy. The hypothesis was tested with Analysis of Covariance (ANCOVA) statistic since the dependent variable is continuous with pretest as a covariate that is also continuous and the independent variable is categorical. The results of data analysis are shown in Table 2.

Table 2: Summary of the ANCOVA of teaching strategy and students' academic achievement in Kinetic Theory of Gases

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	521.520[a]	2	260.760	6.631	.002	.102
Intercept	21013.918	1	21013.918	534.386	.000	.820
Pretest	18.805	1	18.805	.478	.491	.004
Treatment	489.083	1	489.083	12.437*	.001	.096
Error	4600.847	117	39.323			
Total	148920.000	120				
Corrected Total	5122.367	119				

*p < .05

The results in Table 2 indicate that the calculated F value is 12.437 and is statistically significant (p =.001) at .05 significance level and (1, 117) degrees of freedom. That means there is a significant difference in the mean academic achievement of students taught with think-pair-share strategy and lecture instructional and strategy. Therefore, the null hypothesis is rejected. Going by the partial eta squared value (.096), the effect of treatment or teaching strategy on students' academic achievement is small. Only 9.6 per cent of the variance in students' academic achievement in Kinetic Theory of Gases can be accounted for by the teaching strategies. Overall, the ANCOVA analysis result revealed that think-pair-share strategy is more effective than lecture strategy, even after controlling for the effect of pretest scores.

Hypothesis 2

There is no significant difference in the mean achievement scores of male and female students taught Kinetic Theory of Gases with think-pair-share strategy. The hypothesis was tested with Analysis of Covariance (ANCOVA) statistic since the dependent variable is continuous with a pretest that is also continuous and the independent variables are categorical. The result of data analysis is shown in Table 3.

Table 3: Summary of the ANCOVA of male and female students' mean academic achievement in Kinetic Theory of Gases when taught with think-pair-share strategy and Lecture instructional strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	626.502[a]	4	156.625	4.006	.004	.122
Intercept	20512.052	1	20512.052	524.679	.000	.820
Pretest	17.084	1	17.084	.437	.510	.004
Treatment	221.708	1	221.708	5.671	.019	.047
Gender	99.175	1	99.175	2.537	.114	.022
Treatment * Gender	26.661	1	26.661	.682*	.411	.006
Error	4495.865	115	39.094			
Total	148920.000	120				
Corrected Total	5122.367	119				

*P > .05

The results in Table 3 shows that the calculated F value for the interaction of gender and treatment is .682 and it is not statistically significant (p =.411 at .05 significance level and (1,115) degrees of freedom. That means male and female students taught with think-pair-share strategy and lecture instructional strategy do not significantly differ in their mean academic achievement in Kinetic Theory of Gases when the effect of their pretest knowledge is removed. Therefore, the null hypothesis is retained.

Going by the partial eta squared value (.006), the combined effect of teaching strategy and gender on students' academic achievement is very small. Only 0.6 per cent of the variance in students' academic achievement in Kinetic Theory of Gases can be accounted for by the interactive effect of teaching strategies and gender.

Hypothesis 3

There is no significant interaction effect of teaching strategies and gender on students' achievement in Kinetic Theory of Gases. The hypothesis was tested with Analysis of Covariance (ANCOVA) statistic since the dependent variable is continuous with a pretest that is also continuous and the independent variables are categorical. The result of data analysis is shown in Table 4.

Table 4: Summary of the ANCOVA of interactive effect of treatments (think-pair-share and lecture instructional strategies) and gender on students' academic achievement in Kinetic Theory of Gases

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	612.007[a]	4	153.002	10.711	.000	.271
Intercept	4485.919	1	4485.919	314.028	.000	.732
Pretest of Achievement	57.087	1	57.087	3.996	.048	.034
Treatment	.246	1	.246	.017	.896	.000
Gender	174.178	1	174.178	12.193	.001	.096
Treatment * Gender	270.094	1	270.094	18.907*	.000	.141
Error	1642.784	115	14.285			
Total	282105.000	120				
Corrected Total	2254.792	119				

*P < .05

The results in Table 4 shows that the calculated F value for the interaction of gender and treatment is 18.907 and it is statistically significant (p =.000) at .05 significance level and (1,115) degrees of freedom. That means male and female students taught with think-pair-share strategy and lecture instructional strategy significantly differ in their mean achievement scores in Kinetic Theory of Gases when the effect of their pre-treatment achievement is removed. Therefore, the null hypothesis is rejected.

In spite of the significant influence, the partial eta squared value (.141) shows that the interactive effect of teaching strategy and gender on students' academic achievement is small. Only 14.1 per cent of the variance in students' achievement in Kinetic Theory of Gases can be accounted for by the interactive effect of teaching strategies and gender.

To determine the magnitude of the mean achievement scores of male and female students exposed to various treatments, a multiple classification analysis was done. The results are shown in Table 5.

Table 5: Multiple classification analysis of students' mean achievement of Kinetic Theory of Gases under various treatment conditions and gender.

Categories	N	Unadjusted variation	Adjusted for independent + covariates deviation	Partial Eta Squared
Think-pair-share Male	30	48.800	48.770	.141
Think-pair-share Female	34	49.588	49.487	
Lecture instructional strategy Male	11	52.818	52.400	
Lecture instructional strategy Female	45	45.867	46.065	

As shown in the table, male students taught with lecture instructional strategy have the highest adjusted mean score, followed by female students taught with think-pair-share strategy; male students taught with lecture strategy, and finally female students taught with lecture instructional strategy, in decreasing order of magnitude of mean achievement scores.

Discussion of findings

This section talks directly on the discussion of findings that resulted from the results of analysis. This is done hypothesis-by-hypothesis.

Mean achievement scores of students taught Kinetic Theory of Gases with think-pair-share strategy and those taught with lecture strategy

Hypothesis one states that, there is no significant difference in the mean achievement scores of students taught Kinetic Theory of Gases with think-pair-share strategy and those taught with lecture strategy. The finding with respect to hypothesis one, showed that there was a significant positive effect of think-pair-share on students' academic achievement in Kinetic Theory of Gases. It then means that the students who were exposed to the use of think-pair-share retained concepts in Kinetic Theory of Gases higher than their counterparts taught with lecture instructional strategy. The findings also imply that students who are given the opportunity to study using alternative channels outside the usual mode of learning meet problems and think of ways to solve them, such students will have the opportunity of learning faster and more effectively than those who are not exposed to such alternative channels in Kinetic Theory of Gases. Hence, it could be said that the use of think-pair-share are engaging and has a positive impact on students compared to their counterparts exposed to lecture instructional strategy. The findings here is important because a lot of students are aware of the advantages of adopting a research based approach to learning. This will make them to be open to experiences, learn more facts, carry out extensive learning and develop ability to assimilate the information since the strategy is strictly student centered. It is a fact that learning through personal experiences or guided participatory learning can have significant improvement on the learners' achievement.

The finding of hypothesis one is in line with that of Achufusi, OKonkwo and Wisdom (2023) who conducted a study to determine the effect of the think-pair-share instructional strategy on senior secondary school students' academic achievements and interest in chemistry. The findings show that students taught using the think-pair-share strategy performed better and had a higher interest in chemistry than those taught using the lecture method.

The finding of hypothesis one is also in line with that of Omeje (2024) who study investigated the effect of think-pair share instructional strategy on senior secondary school students' academic achievement in acid-base reactions in Enugu Education zone of Enugu State. The findings of the study showed that students who were taught acid-base reactions using think-pair share instructional strategy had improved academic achievement than their counterparts who were taught using lecture method.

Mean achievement scores of male and female students taught Kinetic Theory of Gases with think-pair-share strategy

Hypothesis two states that there is no significant difference in the mean achievement scores of male and female students taught Kinetic Theory of Gases with think-pair-share strategy. The result of the findings showed that gender of the participants has no significant influence on the students' achievement in Kinetic Theory of Gases. This finding means that there is no gender difference based on achievement when students are exposed to teaching strategies in some cases. That is, given the same opportunity, both male and female can achieve high in Kinetic Theory of Gases.

This present finding is not in agreement with the earlier view of Nnoli (2024) who conducted a study to investigate the impact of the Think-Pair-Share (TPS) strategy on students' academic performance in Chemistry at the Awka Education Zone, establishing its significance in addressing persistent poor performance in the subject. Results showed that there was a significant difference in achievement scores between students taught with TPS and those taught with the lecture method, as well as between Male and Female Students taught with TPS.
The finding of hypothesis two is also not in line with that of Obikezie, Ezeliorah and Okafor (2023) who conducted a study to investigate the effect of generative learning model on secondary school students' academic achievement in Chemistry. It covered the topics of kinetic theory of gases and gas laws. The findings of the study revealed that, there is no significant difference male and female academic achievement in Chemistry. Based on the findings of the study, it was concluded that the use of generative learning model instructional strategy improves academic achievement of Chemistry students not minding the gender.

Interaction effect of teaching strategies and gender on students' achievement in Kinetic Theory of Gases

Hypothesis three states that there is no significant interaction effect of teaching strategies and gender on students' achievement in Kinetic Theory of Gases. The result of the finding in hypothesis three showed that there was no interactive effect of treatment (think-pair-share and lecture instructional strategies) and gender on students' academic achievement in Kinetic Theory of Gases in the study area. This finding means that when all the variables of the treatment (think-pair-share and lecture instructional strategies) and gender are combined, and examined over students' achievement, there was a significant interaction effect on the students' achievement to learn Kinetic Theory of Gases. This indicates that the use of think-pair-share when interacted with sex of students affected students' achievement in Kinetic Theory of Gases. The finding agrees with findings of Edem, Nyakno and Assan (2023) conducted a study to investigate the influence of think pair share instructional strategy on Senior Secondary School Students Academic Performance and Retention in Science Subject in Akwa Ibom North East Senatorial District. The findings of the study revealed that there was no significant interacting effect of gender and teaching methods on students mean Achievement in science subject.

The finding is also in conformity with Achufusi, OKonkwo and Wisdom (2023) who conducted a study to determine the effect of the think-pair-share instructional strategy on senior secondary school students' academic achievements and interest in chemistry. The findings show that there was no interaction effect of gender and method of instruction on students' academic achievement, as well as on academic interest of student in chemistry.

Conclusion

The strategy used in the process of teaching and learning is highly critical to vital effect on students' academic achievement taught with think-pair-share strategy. Think-pair-share learning has proved to be one of such strategy that is effective in enhancing students' academic achievement in Kinetic Theory of Gases. Think-pair-share learning involves a learner-centered approach to instructional where students are given opportunity to learn and enhance higher learning experience. Meanwhile, there is no interaction effect of sex as a moderator variable with think-pair-share strategy; was somehow not significant when jointly combined. In conclusion, the findings revealed that:

i. The mean academic achievement of students taught Kinetic Theory of Gases with think-pair-share strategies is significantly higher than that of students taught with lecture instructional strategy.

ii. Male and female students taught with think-pair-share strategy and lecture instructional strategy do not significantly differ in their mean academic achievement in Kinetic Theory of Gases when the effect of their pretest knowledge is removed.

iii. There was no interactive effect of treatment (think-pair-share and lecture instructional strategies) and gender on students' academic achievement in Kinetic Theory of Gases in the study area.

Recommendations

Based on the findings of the study, it was recommended among others that;

1. Ministry of Education should provide in-service training for chemistry teachers on appropriate techniques on the use of think-pair-share strategy.
2. Teachers should adopt the use of think-pair-share strategy to enhance students' academic achievement in Kinetic Theory of Gases.
3. Both male and female students should be exposed to think-pair-share strategy in learning chemistry concepts.

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