



Improving Secondary School Students' Achievement in Chemistry Through Interaction Pattern Approach

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Abstract

The study determined the effect of the interaction pattern approach on secondary students' achievement in Chemistry. The study was conducted in Awka South Local Government Area of Anambra State. The study employed a quasi-experimental research design. Specifically, the pre-test and post-test non-equivalent control group design was used. A sample size of 112 (45 male & 67 female) out of the 1,522 senior secondary two (SS2) Chemistry students was selected using purposive and simple random sampling techniques. A 50 multiple-choice objective items Chemistry Achievement Test (CAT) developed by the researchers was the instrument used for data collection. The reliability index of 0.92 was obtained for CAT using Kendall's Coefficient of Concordance (w). Data were analyzed using mean and standard deviation to answer the research questions, and Analysis of Covariance (ANCOVA) was used to test the hypotheses at a 0.05 level of significance. The study's findings revealed that the interaction pattern approach (IPA) significantly improves students' achievement in Chemistry compared to the conventional lecture approach (CLA). Gender has no significant influence on students' achievement in chemistry when taught using IPA. Also, there is no significant interaction effect of instructional approaches and gender on students' achievement in chemistry. Based on the findings, it was recommended that chemistry teachers use IPA to improve students' achievement in the subject and promote gender-friendly chemistry teaching and learning.

Keywords: Interaction pattern approach, achievement, chemistry, gender

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Introduction

Chemistry plays a vital role in understanding various phenomena in our everyday lives. It is a discipline within the natural sciences that primarily addresses the attributes of substances, the transformations they experience, and the fundamental laws that govern these phenomena (Plekhanov et al., 2023). Chemistry emerges from the foundational principles of physics, extending its relevance to various scientific domains including life sciences, engineering, technology, earth sciences, and medicine (Dr. Nwafor et al., 2024). Notwithstanding the significance above, students' academic achievement in this subject has been less than satisfactory with evaluations indicating considerable inconsistency (WAEC Chief Examiner, 2016–2022). Multiple factors, including psychological determinants such as self-esteem (Walker-Clarke et al., 2022), characteristics intrinsic to students, institutional factors, innovative pedagogical methodologies, and conventional lecture approaches have been identified as contributing to this subpar and erratic achievement among students in chemistry. To enhance students' achievement this study proposed the interaction pattern approach. This methodology promotes engagement and active participation among students, educators, and instructional resources.

The Interaction Pattern approach within the educational setting constitutes a dynamic process wherein the instructor and the learners exert reciprocal influences upon one another through their verbal and non-verbal communication in pursuit of educational objectives. In an interaction pattern pedagogical strategy, as articulated by (Darling-Hammond et al., 2020) Educators establish the overarching norms of conduct during instructional sessions, while students concurrently develop specific behaviors that align with these established norms. Classroom interactions facilitate the enhancement of students' active participation and engagement throughout the teaching-learning continuum. Therefore, within the context of this research, classroom interaction encompasses the entirety of activities occurring within the scientific learning environment, involving the teacher and students, interactions among students, and engagement with instructional materials.

Empirical investigations have demonstrated the effectiveness of IPA in improving academic outcomes. Several empirical investigations have been conducted to ascertain the effectiveness of the interaction pattern approach on students' academic achievement. For example, (Cerezo et al., 2016) Revealed that the application of interaction patterns in the instruction of geometric construction significantly improved the student's achievement in this area and that gender was not a significant factor in the treatment. In addition, the interaction pattern methodology has demonstrated effectiveness across various disciplines, including mathematics. More so, (Chang et al., 2022) Demonstrated that there exist statistically significant disparities at a threshold of 0.05 between the mean scores of middle school mathematics educators after the implementation of the cognitive achievement assessment, observation rubric, and product evaluation framework about the competencies required for the development of interactive lessons, attributable to the influence of varying interaction modalities within the electronic training milieu. In addition to the instructional approach, gender could be a factor that influences students' academic achievement.

However, the influence of gender on students' achievement in Chemistry using the IPA has not been definitively established. (K. M. A. Ahamed Zubair, 2024) Contended that science subjects are perceived through a masculine lens within the educational system, like (Safitri, 2023); (Stewart-Williams & Halsey, 2021) Revealed that female students outperformed their male counterparts in the realm of Chemistry, whereas, (Nwafor et al., 2024) Reported no statistically significant difference in the acad

emic achievement of male and female students in Chemistry. From the preceding analysis, it can be inferred that the impact of gender on student achievement in the sciences, particularly in Chemistry, has not been skewed in any direction, as research continues to reflect divergent perspectives. Nevertheless, the majority of these studies were conducted outside the specific subject area of the current investigation, and none have explored the influence of gender on the academic achievement of students in Chemistry using an interaction pattern approach within the area of the present study. Thus, this study addresses the identified gap. Therefore, the objectives of the study were to determine the mean achievement scores of students in chemistry when taught using the interaction pattern approach and conventional lecture approach; ascertain the influence of gender on the mean achievement scores of students in chemistry, and determine the interaction effect of approaches and gender on Chemistry students' achievement.

Methodology

Research Design

The study adopted a quasi-experimental research design. Specifically, the pre-test and post-test non-equivalent control group design was used. This design was used because the researchers used intact classes (non-randomized groups) for the study. According to Nworgu (2018), quasi-experimental design is often used in classroom experiments when the experimental and control groups are naturally assembled in intact classes so as not to disrupt the academic program of the schools involved in the study.

Participants

The study was carried out in Awka South Local Government Area of Anambra State, Nigeria. The targeted population was all the 1,522 senior secondary two (SS2) Chemistry students in the in Awka South Local Government Area of Anambra State. The Local Government Area has a total of 19 public secondary schools. A sample size of 112 SS2 chemistry students was drawn through a multi-stage sampling procedure. Firstly, two co-educational schools were selected through a purposive sampling technique. In each of the two schools, an intact class was selected. Moreover, the two intact classes were randomly assigned to the experimental and control groups respectively. The experimental group consisted of 51 students (21 males & 30 females) while the control group contained 61 students (24 males & 37 females).

Instruments

Researchers developed the Chemistry Achievement Test (CAT) which was made up of 50 multiple-choice objective items used for data collection. The lesson plan and the CAT were given to three experts for validation; one from the Department of Education Foundations (Measurement & Evaluation Unit), and two from the Department of Science Education (Chemistry Unit), all from Nnamdi Azikiwe University, Awka, Anambra State. The content validity of CAT was established using the test blueprint constructed by the researchers based on the cognitive skills test of

knowledge, comprehension, analysis, synthesis, and evaluation. The CAT was administered to the chemistry students in the experimental and control groups for both the pre-test and post-test respectively. Kendall's Coefficient of Concordance (w) was used to obtain a reliability index of 0.92 for CAT.

Experimental Procedure

The experiment lasted for six weeks, as the regular chemistry teachers in the two sampled schools served as the research assistants for the study. In the first week, the researchers trained the regular chemistry teachers. Hence, the chemistry teacher in the experimental group was trained using a lesson plan on IPA while the other was exposed to the CLA. During the second week, the intact classes of the two groups were pre-tested just before the commencement of the treatment. From the third week to the fifth week, the treatment was given while the post-test was administered on the sixth week.

Data Analysis Procedure

The data from the pre-test and post-test of the groups were analyzed using SPSS Version 25. Mean and standard deviation were used in answering the research question while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Results

The results of the study are presented below according to the objectives of the study. Table 1 was used to show the mean achievement scores of students taught chemistry using the interaction pattern approach and those taught with the conventional lecture approach while Tables 3 and 4 were used to show the mean achievement scores of male and female students in chemistry when taught with interaction pattern approach and the interaction effect of approaches and gender on students' achievement.

Table 1. Pre-test and post-test mean and standard deviation achievement scores of students taught chemistry using the interaction pattern approach and those taught with the conventional lecture approach

Methods	Pre-test			Post-test		
	N	Mean	SD	Mean	SD	Mean Gain
IPA	51	37.41	8.61	75.57	5.56	38.16
CLA	61	34.69	7.50	59.41	4.58	24.72

The result in Table 1 shows that the students taught chemistry using IPA had a pre-test mean achievement score of 37.41 with a standard deviation (SD) score of 8.61 and a post-test mean achievement score of 75.57 with an SD score of 5.56. The mean gain obtained when students are taught using IPA was 38.16. On the other hand, students taught chemistry using CLA had a pre-test mean achievement score of 34.69 with an SD score of 7.50 and a post-test mean achievement score of 59.41 with an SD score of 4.58. The mean gain obtained when students are taught using CLA was 24.72. The difference between the gained mean achievement scores of the students between the groups is 13.44 in favor of IPA. The result implies that students who were taught

chemistry using IPA achieved better than their counterparts taught using CLA. Hence, the interaction pattern approach is more effective in teaching chemistry than the conventional lecture approach.

Table 2. Analysis of covariance (ANCOVA) of the significant difference in the mean achievement scores of students taught chemistry using approaches and gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Dec.
Corrected Model	7476.919 ^a	4	1869.230	77.491	.000	.743	
Intercept	19019.620	1	19019.620	788.479	.000	.881	
Pretest	175.289	1	175.289	7.267	.008	.064	
Approaches	6601.276	1	6601.276	273.663	.000	.719	Sig.
Gender	1.652	1	1.652	.068	.794	.001	NS
Approaches * Gender	42.721	1	42.721	1.771	.186	.016	NS
Error	2581.045	107	24.122				
Total	509348.000	112					
Corrected Total	10057.964	111					

Table 2 shows that $F(1, 107) = 273.663$, $P = 0.000 < 0.05$ alpha level, therefore, hypothesis 1 was rejected. The inference drawn is that there is a significant difference between the mean achievement scores of students taught Chemistry using IPA and those taught Chemistry using CLA in favor of the IPA group. In terms of effect size, Table 2 also shows that Partial Eta Squared .719 (71.9%) in achievement scores of students in Chemistry is attributed to the treatment which is large enough to be effective.

Table 3. Mean and standard deviation of the pre-test and post-test achievement scores of male and female students in chemistry when taught using the interaction pattern approach

IPA	Pre-test			Post-test		
	N	Mean	SD	Mean	SD	Mean Gain
Male	21	35.14	7.34	76.10	5.20	40.96
Female	30	39.00	9.18	75.20	5.86	36.20

The result in Table 3 shows that male students taught chemistry using IPA had a pre-test mean achievement score of 35.14 with an SD score of 7.34 and a post-test mean achievement score of 76.10 with an SD score of 5.20 while their female counterparts had a pre-test mean achievement score of 39.00 with a standard deviation score of 9.18 and a post-test mean achievement score of 75.20 with a standard deviation score of 5.86. The mean gain obtained between the pre-test and post-test of the male and female students in chemistry is 40.96 and 36.20 respectively. This implies that the male students slightly achieved higher than their female counterparts when taught chemistry using the approaches. To test if the difference is significant, the hypothesis below was tested.

Table 4: Analysis of covariance (ANCOVA) of the significant difference in the mean achievement scores of male and female students taught chemistry using the interaction pattern approach and gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	21.914 ^a	2	10.957	.345	.710	.014
Intercept	13157.927	1	13157.927	414.261	.000	.896
Pretest	12.013	1	12.013	.378	.541	.008
Gender	14.740	1	14.740	.464	.499	.010
Error	1524.596	48	31.762			
Total	292788.000	51				
Corrected Total	1546.510	50				

Table 4 shows that the probability associated with the calculated value of F (.464) for the mean achievement scores of male and female students in chemistry when taught using IPA is .499. Since the probability value of .499 is greater than the 0.05 level of significance ($p > .05$), the null hypothesis was not rejected. Hence, gender has no significant influence on the mean achievement scores of students in chemistry. This can also be confirmed from the effect size as seen in Table 4 which shows that the Partial Eta Squared .010 (1.0%) in achievement scores of the students is attributed to the effect of gender. The result in Table 2 reveals that for the interaction effect of instructional approaches and gender on students' achievement in chemistry, an F-ratio of 1.771 was obtained with an associated probability value of .186 which is greater than 0.05 set as the benchmark. This implies that the null hypothesis which stated that there is no significant interaction effect of instructional approaches and gender on students' achievement in chemistry is not rejected. In terms of effect size, Table 2 shows that Partial Eta Squared .016 (1.6%) in achievement scores of students in Chemistry is attributed to the interaction effect of gender and instructional approaches which is very small. Moreover, Figure 1 as seen below shows that the profile plots of two instructional approaches on male and female students' achievement scores are parallel to each other without any intersection. By implication, the effect of the two instructional approaches on the mean achievement scores of students in Chemistry does not depend on their gender.

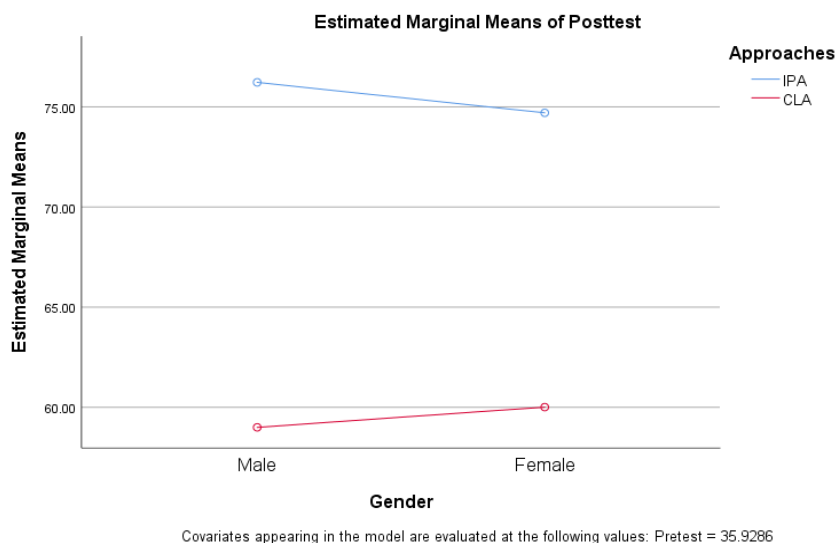


Figure 1. The interaction effect of instructional approaches and gender on students' achievement in chemistry.

Discussion

The findings of the study showed that students taught chemistry using the interaction pattern approach had higher achievement scores than their counterparts exposed to the conventional lecture approach. Further analysis showed a significant difference between the mean achievement scores of students taught chemistry using PLA and CLA in favor of the IPA. The reason for the higher achievement may be related to the fact that students were more actively involved in the IPA classrooms as they interacted and engaged with the teachers, themselves, and the instructional materials. Also, the interaction pattern approach improves students' participation and involvement during the teaching-learning process; thus enriching students' learning experience and improving their achievement. The findings imply that Chemistry teachers should adopt IPA to enhance students' achievement in the subject. This can be achieved through conferences and seminars to train chemistry teachers and other teachers on the efficient use of IPA. The findings of this study agree with (Parker et al., 2022), theory of cognitive learning which states that the basis of all learning is the child's activity as the child interacts with the physical and social environment. In the view of the theory, learners actively build knowledge through exploration and interaction with their environment. It sees the teacher as a facilitator or a guide in the teaching and learning process whose role is to provide a rich environment that encourages interaction and exploration of the students just as it is done in the interaction pattern approach. The findings of this study are in agreement with the findings of (Osakwe et al., 2023) This revealed that the use of Interaction Patterns in teaching geometric construction to secondary school students enhanced their achievement in geometric construction. (Modupe, 2021) Revealed that classroom interaction patterns teaching strategy significantly influenced students' achievements in Basic Electricity and keyboarding aspects of music respectively. Also, (Cerezo et al., 2016) Revealed that students taught with the interaction patterns strategy perform better than those taught with the conventional method. In the same (Farhi et al., 2024), that there are statistically significant differences between the average scores of middle school mathematics teachers in the post-application of the cognitive achievement test in the e-training environment as a result of the interaction patterns approach.

The findings of the study revealed that the male students slightly achieved higher than their female counterparts when taught chemistry using the IPA. However, further analysis showed that gender has no significant influence on the mean achievement scores of students in chemistry. The reason could be because of the equal opportunity the IPA provided for both male and female students. Therefore, giving both genders the opportunity to explore during the learning process through effective interaction with teachers, students, and materials. Hence, IPA is a gender-friendly instructional approach. The findings imply that IPA should be used to foster a gender-friendly environment in Chemistry classes and other academic areas. Teachers, curriculum designers, and other educational stakeholders must thereby acknowledge and take into account students' IPA when creating the curriculum. The finding of the study is in agreement with (Paz-Baruch & Spektor-Levy, 2024), who stated that there is no significant difference between the gender of the students and their achievement in geometric construction. Also, in line with the findings of this study, (Ibrahim et al., 2022) reported that gender has no significant difference in the mean cognitive achievement scores in biology due to the application of classroom interaction patterns. This is against the finding of (Lindner et al., 2022), who revealed that Girls participated in fewer interactions than boys meaning that boys distinctly dominated the biology lesson, they were more active, more willing, commented impulsively, and made more contiguity with the students-teachers than girls. Also, the finding is in disagreement with the (Yuan, 2024) that gender is an affecting factor in the process of teacher-student interaction.

Also, the findings of the study showed that there is no significant interaction effect of instructional approaches and gender on students' achievement in chemistry. Hence, the effect of the two instructional approaches on the mean achievement scores of students in Chemistry does not depend on their gender. The researchers opined that the result of no significant interaction effect of gender and instructional approaches on students' achievement in Chemistry may be because the interaction pattern approach gave the students an equal opportunity to achieve more in learning activities regardless of gender. In line with the findings of this study is that of (Nurudin et al., 2019) who showed no significant interaction effect of gender and method of instruction on students' achievement geometric construction aspect of mathematics. This finding is also in agreement with the findings of (Rudhumbu, 2022), who averred that there is no significant interaction effect of gender and teaching methods on students' achievement in building technology respectively.

Conclusions

The researchers concluded based on the findings that the interaction pattern approach improves students' achievement in chemistry. Also, IPA creates a non-gender-biased environment in the learning process because gender has no significant influence on the mean achievement scores of students in chemistry in the study. Therefore, the researchers suggest that future researchers should investigate the effect of IPA on students' achievement in other school subjects using larger samples.

Conflict of Interest

The authors declare no conflict of interest.

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