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EFFECT OF INTERACTIVE SIMULATION INSTRUCTIONAL STRATEGY ON THE ACADEMIC ACHIEVEMENT OF SENIOR SECONDARY SCHOOL II (SS2) CHEMISTRY STUDENTS IN ABIA STATE, NIGERIA

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Abstract

This study investigated the effect of Interactive Simulation Instructional Strategy on the Academic Achievement of Senior Secondary School II (SS2) Chemistry Students in Abia State, Nigeria. Three research questions and corresponding three hypotheses respectively guided the study. The study adopted a quasi-experimental, pretest posttest non-equivalent control group research design and was carried out in Abia state. A sample of 75 secondary school (SSII) students drawn from two public co-educational secondary schools in the State was used for the study using multi-stage procedure. One intact class each was sampled in each of the two sampled schools which were assigned into one experimental and one control group. Data were collected using a 50-multiple choice questions titled: Chemistry Achievement Test (CAT). The instrument was developed by the researchers and subjected to face and content validation. The validation was carried out by three experts, two from Chemistry Education and one in measurement and evaluation all from Department of Science Education, Michael Okpara University of Agriculture Umudike, Abia state Nigeria. The instrument was tested for reliability and subjected to analysis using Kudder Richardson (K-R_{20}) formula to determine the internal consistency which yielded an index of 0.78. Before and after the treatment that lasted for four weeks, the copies of the instrument were administered to the students by their regular Chemistry teachers. The data collected from the students were analyzed using mean and standard deviation to answer the research questions, while the Analysis of Covariance (ANCOVA) was used to test the null-hypotheses at 0.05 level of significance. Based on the

analyses, the findings revealed that students taught Chemistry using Interactive Simulation strategy achieved significantly higher than those taught using lecture method. Gender had no significant influence on students' achievement, and there was no significant interaction effect of gender and teaching strategy on students' achievement in Chemistry.

Keywords: Interactive Simulation Strategy, Academic Achievement, Electrolysis, Chemistry Education, Secondary School Students

Introduction

Science education plays a crucial role in the technological, scientific, and economic advancement of any nation. This is because it provides learners' with the knowledge and skills required for innovation, problem-solving, and sustainable development among others. Amongst the core Science, Technology, Engineering and Mathematics (STEM) subjects, Chemistry occupies a central position because it explains the composition, structure, and properties of matter and the changes it undergoes. This makes it essential in fields such as medicine, engineering, agriculture, pharmacy, environmental science, and industrial production (Eilks & Hofstein, 2013).

Chemistry has been defined by different scholars in line with its scope and relevance. Miller (2024) described Chemistry as the study of matter, its composition, structure, properties, and the changes it undergoes during chemical reactions. In another disposition, Okeke (2019) explained Chemistry as the science that deals with the composition, structure, properties, and transformations of matter with relevance to everyday life and national development. Similarly, Opara and Waswa (2018) viewed Chemistry as a discipline concerned with understanding substances and their interactions. These definitions show that Chemistry is both abstract and practical, requiring effective instructional strategies for meaningful learning.

Although, despite its importance, students' achievement in Chemistry has remained persistently low, especially in abstract topics such as Electrolysis. For instance, studies by Eze and Okeke (2021), reported that students often perceive Chemistry as difficult due to its abstract nature and the dominance of lecture-based teaching methods. WAEC Chief Examiners' Reports (2020–2024) also consistently revealed poor performance in Chemistry, particularly in Electrolysis, stoichiometry, and chemical bonding.

Electrolysis is a concept in Chemistry that involves the decomposition of compounds using electric current. It includes abstract processes such as ion movement, electrode reactions, and electron transfer. These processes are not visible, making the topic difficult for learners when taught using conventional lecture methods alone. Yusuf and Bello (2019) noted that students experience greater difficulty in understanding science concepts when instruction lacks visualization and interaction, leading to poor achievement and weak retention.

In many secondary schools, the lecture method remains the dominant instructional approach. This method is teacher-centred and positions learners as passive recipients of knowledge rather than active participants in the learning process. As a result, students often resort to memorization of concepts without developing deep conceptual understanding, particularly in abstract topics such as Electrolysis. This instructional limitation contributes significantly to persistent low academic achievement in Chemistry. This position is supported by constructivist learning theory, which emphasizes that meaningful learning occurs when learners actively construct knowledge through interaction, exploration, and engagement rather than passive listening (Piaget, 1972; Vygotsky, 1978). In the same vein, Akinbobola and Afolabi (2022) observed that teacher-centred instructional approaches restrict students' participation and reduce their ability to develop higher-order thinking skills in science subjects. Similarly, Okeke and Ochuba (2016) reported that the continued reliance on lecture methods in Chemistry classrooms contributes to poor understanding of abstract concepts and low academic performance among students. Furthermore, Olatunde and Okeke (2022) found that students exposed to traditional teaching methods demonstrated weak conceptual understanding and difficulty in applying Chemistry principles to problem-solving situations.

To address these challenges, educational researchers have advocated for the use of innovative learner-centred instructional strategies. One such approach is the Interactive Simulation Instructional Strategy. Interactive Simulation involves the use of virtual models and digital representations to help learners visualize and interact with scientific processes, thereby making abstract concepts more concrete and understandable.

Okeke (2019) found that simulation-based instruction significantly improves students' visualization of scientific processes and enhances academic achievement in Chemistry. Similarly, Eze (2020) reported that interactive instructional methods improve students' engagement and performance in science subjects. Yusuf and Bello (2019) also found that simulation-based learning enhances conceptual understanding and academic achievement in science subjects.

The effectiveness of Interactive Simulation can be explained using constructivist learning theory. Piaget (1972) and Vygotsky (1978) explained that learners construct knowledge actively through interaction with their environment. Interactive Simulation supports this by allowing students to explore and manipulate virtual scientific processes, thereby promoting active learning and better understanding.

Academic achievement refers to the measurable performance of learners in academic tasks and assessments. It is the scholastic standing of a student at a given time, reflecting the individual's intellectual abilities and mastery of subject content (Adeyemi, 2018). Academic achievement is an important indicator of educational progress and is often used to evaluate the effectiveness of teaching strategies (Schnitzer, 2015; Mgberekpen, 2013). In Chemistry, it reflects students' ability to understand concepts, apply principles, and solve problems correctly. Improving

instructional strategies is therefore essential for enhancing students' achievement in difficult topics such as Electrolysis. Beyond the measurement of students' academic performance in Chemistry, it is also important to consider factors that may influence such achievement, among which gender has been widely examined in science education research.

Gender is another important variable in science education. It refers to socially constructed roles, behaviours, and expectations associated with males and females in society (World Health Organization, 2022). Studies have shown mixed findings regarding gender differences in Chemistry achievement. Okeke (2021) reported slight differences between male and female students, although not statistically significant. Similarly, Eze (2023) found that gender differences reduce when innovative instructional strategies are used. Yusuf and Bello (2019) further reported that gender does not significantly influence students' academic achievement when simulation-based instruction is used. This suggests that Interactive Simulation provides equal learning opportunities for both male and female students.

The interaction effect between gender and instructional strategy is also important in educational research. It examines whether the effectiveness of a teaching method depends on gender differences. Yusuf and Bello found no significant interaction effect between gender and instructional strategy, suggesting that instructional effectiveness is independent of gender.

Despite these findings, there is still limited research on the use of Interactive Simulation Instructional Strategy specifically in teaching Electrolysis in Chemistry within Abia State. Most existing studies focused on general Chemistry concepts, leaving a contextual gap that this study seeks to fill.

Chemistry is a fundamental science subject that is expected to equip students with knowledge and skills necessary for scientific literacy and technological development. Ideally, students are expected to understand Chemistry concepts effectively through engaging and student-centred instructional approaches that promote active participation, conceptual understanding, and practical application of knowledge.

However, the reality in many secondary schools in Nigeria, particularly in Abia State, is different. Teaching is still largely dominated by the traditional lecture method, where students are passive recipients of information. This method limits students' participation and makes it difficult for them to fully understand abstract concepts such as Electrolysis, which require visualization and step-by-step conceptual clarity. As a result, students continue to record poor academic performance in Chemistry in external examinations such as WAEC and NECO.

This persistent poor performance suggests that the conventional method of teaching may not be effective enough in enhancing students' understanding of Chemistry concepts. Although various innovative instructional strategies such as Interactive Simulation have been suggested, there is still limited empirical evidence on their effectiveness in improving students' academic achievement in Electrolysis in Chemistry in Abia State, Nigeria. It is against this background

that this study seeks to determine the effect of Interactive Simulation Instructional Strategy on the academic achievement of Senior Secondary School II students in Electrolysis in Chemistry in Abia State, Nigeria.

The study investigated the effect of Interactive Simulation Instructional Strategy on the Academic Achievement of Senior Secondary School II (SS2) Chemistry Students in Abia State, Nigeria. Specifically, the study determined the difference in the;

1. mean achievement scores of secondary school students taught Electrolysis in Chemistry using Interactive Simulation strategy and lecture method
2. mean achievement scores of male and female secondary school students taught Electrolysis in Chemistry using interactive simulation strategy
3. interaction effect of gender and teaching methods on the mean achievement scores of secondary school students in Electrolysis in Chemistry

The following research questions guided the study:

i. What is the difference in the mean achievement scores of secondary school students taught Electrolysis in Chemistry using Interactive Simulation strategy and lecture method
ii. What is the difference in the mean achievement scores of male and female secondary school students taught Electrolysis in Chemistry using interactive simulation strategy
iii. What is the interaction effect of gender and teaching methods on the mean achievement scores of secondary school students in Electrolysis in Chemistry

The following hypotheses were tested at 0.05 level of significance:

$H0_1$: There is no significant difference between the mean achievement scores of secondary school students taught Electrolysis in Chemistry using interactive simulation strategy and lecture method**.**

$H0_2$: There is no significant difference between the mean achievement scores of male and female students taught Electrolysis in Chemistry using interactive simulation strategy

$H0_3$: There is no significant interaction effect of gender and teaching methods on the mean achievement scores of secondary school students in Electrolysis in Chemistry in Economics

Methodology

The study adopted a pre-test, post-test non-randomized quasi-experimental design involving an experimental group and a control group to determine the effect of the interactive simulation strategy on Senior Secondary Two (SS2) students' achievement in Electrolysis in Chemistry. The study was conducted in Ohafia Education Zone of Abia State, Nigeria, due to persistent

poor performance in Chemistry as reported in WAEC Chief Examiners' Reports. The accessible population comprised 1,180 SS2 Chemistry students in public secondary schools in Ohafia Education Zone of Abia State for the 2025/2026 academic session (Abia State Secondary Education Management Board, 2026). A sample of 75 students (33 males and 42 females) was drawn using multistage sampling involving simple random and purposive techniques. Two co-educational schools were selected, with intact classes assigned to experimental and control groups respectively.

The instrument used for data collection was the Chemistry Achievement Test (CAT)., adapted from passed WAEC and NECO examination questions consisting of 50 multiple-choice items covering Meaning of electrolysis, identifying terms in electrolysis, Faraday's laws of electrolysis, uses of electrolysis. The instrument was face validated by three experts two from Chemistry Education and one in Measurement and Evaluation all from Department of Science Education, all from Michael Okpara University of Agriculture, Umudike, while reliability was established using KR-20, yielding 0.78. A pre-test was administered to determine group equivalence. The experimental group was taught using the interactive simulation strategy, while the control group was taught using the lecture method for four weeks. A post-test followed immediately after treatment. To control extraneous variables, regular Chemistry teachers served as research assistants after training. Data collected were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at the 0.05 level of significance, with pre-test scores serving as covariates. For the research questions, the group with the higher mean gain score was considered to have achieved better academic performance. For the hypotheses, the decision rule was that if the probability (Sig.) value obtained from the ANCOVA analysis was less than or equal to 0.05, the null hypothesis would be rejected; however, if the probability (Sig.) value was greater than 0.05, the null hypothesis would not be rejected.

Results

The results from the data analysis done were presented in the tables below:

Research Question 1

What difference exists in the mean achievement scores of secondary school students taught Electrolysis in Chemistry using Interactive Simulation strategy and lecture method

The results for answering research question 1 were presented in the Table 4.1.

Table 1: Pretest and Posttest achievement mean scores of students taught Chemistry using Interactive Simulation strategy and Lecture method

		Pretest		Posttest		
Group	**N**	$\bar{X}$	**SD**	$\bar{X}$	**SD**	**Mean gain scores**
IS	40	16.15	2.89	30.67	2.93	14.52
Lect. Mtd	35	16.28	2.72	21.33	2.88	5.05
Effect						9.47

IS = Interactive Simulation, Lect. Mtd. = lecture method

The data in Table 1 shows that students taught with the Interactive Simulation strategy recorded a higher post-test mean score (30.67) than those taught with the lecture method (21.33). The mean gain scores further indicate a greater improvement for the Interactive Simulation group (14.52) compared to the lecture group (5.05), with a difference of 9.47 in favour of the Interactive Simulation.

A corresponding hypothesis that addressed the above research question is:

Hypothesis 1

There is no significant difference between the mean achievement scores of secondary school students taught Electrolysis in Chemistry using interactive simulation strategy and lecture method**.**

Table 2: Analysis of Covariance (ANCOVA) on the mean achievement scores of students taught Chemistry using interactive simulation teaching strategy and those taught using lecture method

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Corrected Model	14012.148 [a]	2	7006.074	129.529	.000
Intercept	3355.164	1	3355.164	62.030	.000
Pretest	3109.670	1	3109.670	57.491	.000
Group	3636.165	1	3636.165	67.226	.000
Error	3894.399	72	54.089		
Total	28007.546	75			

Corrected Total	141362.054	74

Significant at 0.05 level of significance

Table 2 shows that the probability (Sig.) value associated with the group effect is 0.000, which is less than the 0.05 level of significance. Therefore, the null hypothesis was rejected. This indicates that there was a significant difference between the mean achievement scores of students taught Electrolysis in Chemistry using the Interactive Simulation strategy and those taught using the Lecture Method. Since students exposed to the Interactive Simulation strategy recorded a higher mean gain score than those taught using the Lecture Method, the difference was in favour of the Interactive Simulation strategy.

Research Question 2

What difference exists in the mean achievement scores of male and female secondary school students taught Electrolysis in Chemistry using interactive simulation strategy?

Table 3: Pretest and Posttest achievement mean scores of Male and Female Students taught Chemistry using interactive Simulation strategy

	Pretest			Posttest		
Gender	**N**	$\bar{X}$	**SD**	$\bar{X}$	**SD**	**Mean gain scores**
Male	17	16.19	2.90	30.86	2.96	14.67
Female	23	16.11	2.86	30.48	2.93	14.37
Effect						0.30

The results in Table 3 revealed that that male students had a slightly higher post-test mean score (30.86) than female students (30.48) under the Interactive Simulation strategy. The mean gain difference (0.30) indicates a marginal advantage for males.

A corresponding hypothesis that addressed the above research question is:

Hypothesis 2

There is no significant difference between the mean achievement scores of male and female students taught Electrolysis in Chemistry using interactive simulation strategy.

Table 4:Analysis of Covariance (ANCOVA) of Achievement scores of male and female Students taught Chemistry using interactive simulation strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	8428.229 [a]	2	4160.505	51.582	.000
Intercept	693.055	1	693.055	8.592	.000
Pretest	5688.293	1	5688.293	70.524	.000
Gender	99.908	1	99.908	1.239	.093
Error	2984.337	37	80.658		
Total	17893.820	40			
Corrected Total	134797.78	39			

Significant at 0.05 level of significance

The results in Table 4 indicate that a probability (Sig.) value of 0.093 was obtained for gender. Since the probability value is greater than the 0.05 level of significance, the null hypothesis was not rejected. Therefore, there was no significant difference between the mean achievement scores of male and female students taught Electrolysis in Chemistry using the interactive simulation strategy.

Research Question 3

What difference exists in the mean achievement scores of secondary school students in Electrolysis in Chemistry?

Table 5: Interaction Effect of Gender and Teaching strategies on Students' Academic Achievements in Chemistry

			Pretest		Posttest	
Group	**Gender**	**N**	$\bar{X}$	**SD**	$\bar{X}$	**SD**
IS	**Male**	17	16.19	2.90	30.86	2.96
	Female	23	16.11	2.86	30.48	2.93
	Differences		**0.08**	**0.04**	**0.38**	**0.03**
	Male	16	16.34	2.81	21.37	2.85
Lecture method	**Female**	19	16.22	2.73	21.29	2.83
	Differences		**0.12**	**0.09**	**0.08**	**0.02**

IS= Integrative Simulation strategy, Lect. Mtd. = lecture method

The results in Table 5 indicates that students taught with the interactive Simulation strategy performed better than those taught with the lecture method, regardless of gender. Although males recorded slightly higher mean scores across both methods, the differences were minimal.

Hypothesis 3

There is no significant interaction effect of gender and teaching methods on the mean achievement scores of secondary school students in Electrolysis in Chemistry

The data for testing hypothesis 3 were analyzed with ANCOVA and the results presented in Table 6.

Table 6: Analysis of Covariance (ANCOVA) of Interaction Effect of Gender and Teaching strategies on Students' Academic Achievements in Chemistry

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	9409.731a	2	4704.866	25.176	.000
Intercept	32451.885	1	32451.885	43.263	.000
Pretest	179.891	1	179.891	2.334	.000
Group	489.669	1	244.835	2.515	.010
Gender	599.645	1	299.823	3.080	.210
Strategies*Gender	2554.271	1	2554.271	2.236	.103
Error	7009.768	72	97.358		
Total	52694.860	75			
Corrected Total	348067.04	74			

Significant at 0.05 level of significance

Table 6 shows that the probability (Sig.) value associated with the interaction between teaching strategy and gender is 0.103. Since the probability value is greater than the 0.05 level of significance, the null hypothesis was not rejected. Therefore, there was no significant interaction effect of gender and teaching strategy on students' achievement in Electrolysis in Chemistry. This implies that the effectiveness of the instructional strategies did not significantly depend on whether the students were male or female.

Summary of Findings

Based on the data analysis, the findings of the study were summarized as follows:

1. The interactive simulation teaching strategy significantly improved students' achievement in Electrolysis in Chemistry compared to the lecture method.
2. Male students had slightly higher mean achievement scores than female students, but the difference was not statistically significant.
3. There was no significant interaction effect of gender and teaching strategy on students' achievement in Electrolysis in Chemistry.

Discussion of the Findings

The discussion of findings was carried out sequentially based on the research questions and hypotheses that guided study.

Discussion of Findings

The discussion of findings was carried out sequentially based on the research questions and hypotheses that guided the study.

The first finding revealed that students taught Electrolysis in Chemistry using the Interactive Simulation Instructional Strategy performed significantly better than those taught using the lecture method. This was evident in their higher post-test mean score (30.67) and greater mean gain score (14.52) compared to the lecture group (21.33 and 5.05 respectively). The ANCOVA result further confirmed that this difference was statistically significant in favour of the Interactive Simulation group ($p < 0.05$). This finding implies that Interactive Simulation is more effective in enhancing students' academic achievement in Chemistry than the traditional lecture method.

This finding is consistent with studies that have demonstrated the effectiveness of technology-supported and simulation-based instructional approaches in improving learners' achievement in science. For example, Yusuf and Bello (2019) reported that simulation-based learning significantly enhances students' understanding and achievement in science subjects. Similarly, Eze and Okeke (2021) found that simulation-based instruction improves students' conceptual understanding and achievement in Chemistry. In addition, Akinbobola and Afolabi (2022) observed that learner-centred instructional strategies, including interactive approaches, significantly improve students' academic performance in science. The superiority of the Interactive Simulation Strategy may be attributed to its ability to make abstract Chemistry concepts such as electrolysis more concrete, interactive, and visually observable, thereby enhancing meaningful learning.

The second finding showed that male students had a slightly higher mean achievement score (30.86) than female students (30.48) when taught using the Interactive Simulation Strategy. However, the ANCOVA result revealed that this difference was not statistically significant ($p > 0.05$). This indicates that gender does not significantly influence students' academic achievement when Interactive Simulation is used.

This finding is consistent with Yusuf and Bello (2019), who reported that gender does not significantly influence students' achievement when simulation-based instructional methods are employed. It also supports the findings of Eze and Okeke (2021), who observed that gender differences in Chemistry achievement tend to reduce or disappear when learner-centred instructional strategies are adopted. This suggests that Interactive Simulation provides an equitable learning environment that supports both male and female students equally.

The third finding revealed that there was no significant interaction effect between gender and instructional strategy on students' academic achievement in Electrolysis in Chemistry. The ANCOVA result showed that the interaction effect was not significant ($p > 0.05$), indicating that the effectiveness of the instructional strategy does not depend on gender.

This finding is in agreement with Yusuf and Bello (2019), who reported that there is no significant interaction effect between gender and simulation-based instructional strategies on students' achievement. It also aligns with constructivist learning theories such as those of Piaget (1972) and Vygotsky (1978), which emphasize that learning outcomes are largely influenced by instructional experiences and social interaction rather than fixed learner characteristics such as gender. This implies that Interactive Simulation is equally effective for both male and female students in improving achievement in Chemistry.

Overall, the findings of this study demonstrate that Interactive Simulation Instructional Strategy is more effective than the lecture method in improving students' academic achievement in Electrolysis in Chemistry, while gender has no significant influence or interaction effect on students' performance.

Conclusion

Based on the findings of the study, it was concluded that the use of Interactive Simulation Instructional Strategy significantly improved students' academic achievement in Electrolysis in Chemistry more than the lecture method. Students taught using the Interactive Simulation strategy demonstrated better understanding and higher academic achievement than those taught using the conventional lecture method. Although male students recorded slightly higher achievement scores than female students, gender had no significant influence on students' academic achievement in Electrolysis in Chemistry. It was therefore concluded that the Interactive Simulation strategy is effective for both male and female students. Furthermore, it was concluded that there was no significant interaction effect of gender and teaching strategy on students' academic achievement in Electrolysis in Chemistry. Hence, the effectiveness of

the Interactive Simulation strategy was not dependent on students' gender but rather on the instructional approach adopted during teaching.

Recommendations

Based on the findings and conclusions drawn from the study, the following recommendations were made:

1. Chemistry teachers should adopt the use of Interactive Simulation Instructional Strategy more frequently in teaching Electrolysis and other difficult concepts in Chemistry in order to improve students' academic achievement better than the lecture method.
2. Educational authorities and professional science education bodies should organize workshops, seminars, and conferences for Chemistry teachers on the effective use of Interactive Simulation strategies in enhancing students' academic achievement in Chemistry irrespective of gender differences.
3. Senior Chemistry educators and school administrators should provide mentorship and professional support to teachers on the integration of simulation-based instructional strategies into classroom instruction in order to enhance students' participation and achievement in Chemistry.
4. Curriculum planners and textbook authors should incorporate Interactive Simulation activities and digital instructional resources into the Chemistry curriculum to facilitate effective teaching and learning of abstract Chemistry concepts such as Electrolysis.

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