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Effects Of Reflection Instructional Strategy On Students' Achievement In Chemistry In Senior Secondary Schools In Edo State, Nigeria

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ABSTRACT
This study examined the effect of the reflection instructional strategy on the achievement of SS II chemistry students in Edo State, Nigeria, and whether male and female students taught with the strategy differed in achievement. A pretest–posttest non-equivalent control group quasi-experimental design was used. Eighty-five students from two co-educational schools in Etsako West Local Government Area were selected using multistage sampling. One intact class of forty-five students was taught with the reflection strategy for ten weeks and the other forty students was taught the same topics by the lecture method. Data were collected with a 30-item Chemistry Achievement Test and analysed with means, standard deviations and analysis of covariance (ANCOVA) at the 0.05 level. Students taught with the reflection strategy achieved significantly higher than those taught by lecture. Male and female students taught using the reflection strategy did not differ significantly and their mean gains were almost the same. Chemistry teachers in Edo State are encouraged to use the strategy.
Keywords: reflection instructional strategy; chemistry achievement; gender; quasi-experimental design; Edo State

INTRODUCTION

Chemistry is used in medicine, agriculture, manufacturing, petroleum processing, food production and environmental management. The National Policy on Education requires that the subject help students acquire scientific concepts, develop problem-solving skills, see how chemistry relates to other fields, and apply what they learn to everyday life and industry (Federal Republic of Nigeria [FRN], 2013). Shamsuddin et al. (2017) describe chemistry as the backbone of science, technology and industrial development in Nigeria. How well these aims are achieved depends largely on how the subject is taught.

The WASSCE results point to continued difficulties in students' performance in Chemistry in Edo State. Between 2018 and 2024, the proportion of candidates who obtained credit passes (A1–C6) remained below 50% in most years. The credit pass rate was 49.73% in 2018 and dropped to 45.67% in 2019. It declined further to 37.20% in 2020 and increased slightly to 38.59% in 2021. The highest rate recorded during the period was 51.24% in 2022, when 1,860 of the 3,630 candidates obtained credit passes. However, the rate fell again to 46.18% in 2023 and 47.11% in 2024. Thus, fewer than half of the candidates obtained credit passes in six of the seven years reviewed. The lowest performance was recorded in 2020, while 2022 was the only year in which the credit pass rate exceeded 50%. The figures were obtained from WAEC records for Edo State.

Part of the blame has been placed on the lecture method, which dominates chemistry classrooms. The teacher talks, students copy notes, and understanding is tested mostly by recall. The method covers the syllabus quickly, but students get little chance to question ideas, check their own reasoning or link new content to what they already know. Topics such as the mole concept and stoichiometry are abstract and calculation-based, and students taught passively often understand them only on the surface (Agwu & Nmadu, 2023; Musengimana et al., 2021).

The reflection instructional strategy is one learner-centred alternative. Students are asked to think about their learning before, during and after a lesson: they recall what they know, say what they are unsure of, explain why they gave an answer, and connect new material to earlier experience. Ogunbameru and Uwameiye (2012) describe reflection as careful consideration of the assumptions and conclusions one holds in the light of direct experience, so that later action can be informed by it. Teachers also gain from it, since they judge how well a topic was taught and change their approach where necessary (Olaya-Mesa, 2018).

Studies have report that reflection-based instructional strategy raised achievement in chemistry, physics, mathematics and technical subjects (Agbasi & Okeke, 2020; Awodun, 2020; Ogbuanya & Owodunni, 2015; Okigbo & Chukwunyelu, 2025). The findings are not all the same. Canses and Mehmet (2015) found higher scores in the reflection group, but the difference was not significant. Most of the experimental work on reflection in chemistry comes from other parts of Nigeria, and none of the studies reviewed for this paper was carried out in Edo State.

Gender is the second concern. Differences between male and female students in science achievement have been discussed for a long time in Nigeria (Okoro, 2013), and it is not settled whether a change of teaching method reduces them, increases them or leaves them as they are. Ogbuanya and Owodunni (2015) found that boys achieved higher than girls in electronic works trade, with no interaction between technique and gender. Adigun et al. (2015) and Attah and Ita (2017) found no significant gender difference in computer studies and English language respectively. A strategy can be recommended for a whole class only if it works for girls and boys, so gender was included in this study as a moderating variable. The study from which this paper is drawn also measured students' attitude towards chemistry. Only the achievement results are reported here.

Purpose of the Study

The study set out to (a) determine the difference between the achievement of SS II chemistry students taught with the reflection instructional strategy and those taught with the conventional lecture method, and (b) find out whether male and female students taught with the reflection strategy differed in achievement.

Research Questions

1. What is the difference between the mean achievement scores of students taught chemistry with the reflection instructional strategy and those taught with the conventional method?
2. What is the difference between the mean achievement scores of male and female students taught chemistry with the reflection instructional strategy?

Hypotheses

Two null hypotheses were tested at the .05 level of significance.

H_{01}: There is no significant difference between the mean achievement scores of students taught chemistry with the reflection instructional strategy and those taught with the conventional method.

H_{02}: There is no significant difference between the mean achievement scores of male and female students taught chemistry with the reflection instructional strategy.

Theoretical Framework

The study was anchored on two theories. Dewey (1933) described reflective thinking as the careful and persistent examination of a belief in light of the grounds that support it, and regarded it as the way

experience becomes learning. In a chemistry class, students recall earlier work, test it against new information and explain their answers, instead of memorising procedures they cannot justify.

Bandura's (1986) social cognitive theory holds that learning results from the interaction of personal factors, behaviour and the environment. Reflection tasks such as guided worksheets, journals and peer explanation allow students to see how classmates approach a problem, judge their own performance and adjust it. These tasks are the same for every student in a class, so the theory gives no strong reason to expect one sex to gain more than the other. The second hypothesis was therefore stated in the null form.

Related Studies

Agbasi and Okeke (2020) used reflection strategies with an experimental group and lecture with a control group among 200 secondary school students in four schools in Awka Education Zone, Anambra State, and found significantly higher achievement and interest in chemistry in the reflection group. Awodun (2020) worked with 100 SS I physics students in Ekiti State using a pretest–posttest control group design and reported better achievement under reflection teaching. Okigbo and Chukwunyelu (2025) reached a similar result in mathematics with 200 students in Nnewi Education Zone. Ogbuanya and Owodunni (2015) found reflective inquiry more effective than conventional teaching among 105 electronic works students in technical colleges in Lagos State. Canses and Mehmet (2015), with 42 pre-service teachers, found that the reflection group scored higher but not significantly so.

Ogbuanya and Owodunni (2015) reported a gender effect favouring boys in the Lagos study and no interaction between technique and gender, which means the technique worked about equally well for both. Adigun et al. (2015) found a slight, non-significant advantage for boys in computer studies among 275 students in Niger State, and Attah and Ita (2017) found no significant gender influence on English language achievement among 660 SS II students in Calabar. Loka et al. (2019) found no gender difference on reflective thinking scales among dental students. Most of these studies looked at gender in general samples. None of the studies reviewed tested it among secondary school chemistry students taught with a reflection strategy, and this is the gap the present study addresses.

METHOD

Design

The study used a pretest–posttest, non-equivalent control group quasi-experimental design (Table 2). Intact classes were used because students could not be reassigned without disrupting school timetables. The independent variable was teaching method (reflection instructional strategy or conventional lecture), the dependent variable was achievement in chemistry, and gender was the moderating variable.

Table 2: ***Research Design***

Group	Pretest	Treatment	Posttest
Experimental	O_1	X_1	O_2
Control	O_1	X_2	O_2

Note. O_1 = pretest; O_2 = posttest; X_1 = reflection instructional strategy; X_2 = conventional lecture method.

Population and Sample

The population was 4,254 SS II chemistry students in 314 senior secondary schools in Edo State (Department of Research, Planning and Statistics, Edo State Ministry of Education, 2023). A sample of 85 students was drawn in four stages. First, Etsako West Local Government Area was chosen from the 18 local government areas in the state by balloting without replacement. Second, two co-educational schools in the area, Uku Senior Secondary School, Iyuku, and Army Day Senior Secondary School, Auchi, were selected purposively because both offer chemistry, have qualified chemistry teachers and functional laboratories, and have comparable class sizes and facilities. Third, one intact SS II class was picked from each school by balloting where the school had more than one arm. Fourth, the schools were assigned to conditions by the toss of a coin. Uku Senior Secondary School was assigned to the experimental group and Army Day Senior Secondary School to the control group. Classes were not reorganised. Table 3 shows the composition of the sample.

Table 3: **Distribution of Participants by Group and Gender**

Group	Male	Female	Total
Experimental (reflection)	25	20	45
Control (lecture)	22	18	40
Total	47	38	85

Instrument

Data were collected with the Chemistry Achievement Test (CAT), developed by the researcher. It had 30 multiple-choice items with four options (A–D), one of which was correct, and a time limit of one hour. The items covered the content taught during the study. Each questions in chemistry achievement test was scores 2 marks. The same test was used as pretest and posttest.

Face and content validity of the CAT and of the lesson plans were established by the researcher's supervisors and two experts in the Department of Science and Environmental Education, University of Abuja. The experts checked clarity of language, suitability of items for SS II students, and coverage of content against a table of specifications. Their comments were used to revise the instruments before its implementation. For reliability, the CAT was administered once to 40 SS II students at Ughiole Senior Secondary School, Aviele, who were drawn from the same population but did not take part in the main study. The Kuder–Richardson formula 20 gave a coefficient of .79, which is acceptable for a classroom achievement test.

Procedure

An introductory letter from the Head of the Department of Science and Environmental Education, University of Abuja, was presented to the principals of both schools to obtain permission. The regular chemistry teachers in the two schools were trained to served as research assistants. The researcher trained them individually with a training manual covering the lesson plans, the two teaching procedures and the administration of the test, so that the treatment would be delivered in the same way in each school.

The CAT was given as a pretest before teaching began. Both groups were then taught once a week for ten weeks during their regular chemistry periods, with the same topics and the same amount of instructional time. The topics came from the SS II syllabus and included mass and volume relationships in chemical reactions, oxidation and reduction, and the chemistry of sulphur and nitrogen and their compounds. The CAT was administered again at the end of the ten weeks as the posttest.

Experimental group. Each lesson followed four steps: identification of prior knowledge, exploration, discussion and application. Students recalled earlier work, attempted problems, shared their answers with classmates and gave reasons for them. They used reflective worksheets with guided questions, wrote in notebooks for reflection journaling, and tested themselves with flashcards. *Control group.* Students were taught the same content by the conventional lecture method. The teacher introduced the topic, explained it at the board using a chart and the class textbook, worked examples, and set classwork that students attempted individually.

Method of Data Analysis

Means and standard deviations were used to answer the research questions. Analysis of covariance (ANCOVA) with pretest scores as the covariate was used to test the hypotheses at the .05 level of significance. A null hypothesis was rejected when $p \leq .05$. Partial eta squared was calculated from the sums of squares in each ANCOVA table to show the size of the effect.

RESULTS

Research Question One: *What is the difference between the mean achievement scores of students taught chemistry with the reflection instructional strategy and those taught with the conventional method?*

Table 4: **Pretest and Posttest Achievement Scores by Teaching Method**

Group	*N*	Pretest *M*	*SD*	Posttest *M*	*SD*	Mean gain
Reflection	45	18.71	1.05	39.42	1.84	20.71
Lecture	40	18.15	1.52	33.55	2.37	15.40
Difference		0.56		5.87		5.31

Table 4 shows that the two groups began with similar scores (18.71 and 18.15). At posttest the reflection group averaged 39.42 (*SD* = 1.84) and the lecture group 33.55 (*SD* = 2.37). The mean gains were 20.71 and 15.40, a difference of 5.31 points in favour of the reflection group.

Test of Hypotheses

Hypothesis One: There is no significant difference between the mean achievement scores of students taught chemistry using the reflection instructional strategy and those taught using the conventional method.

Table 5: ANCOVA of Posttest Achievement Scores by Teaching Method

Source	Sum of squares	*df*	Mean square	*F*	*p*
Corrected model	732.749	2	366.375	82.00	< .001
Pretest (covariate)	2.521	1	2.521	0.56	.455
Teaching method	715.081	1	715.081	160.05	< .001
Error	366.356	82	4.468		
Corrected total	1099.106	84			

After adjusting for pretest scores, teaching method had a significant effect on achievement, $F(1, 82) = 160.05$, $p < .001$, partial $\eta^2 = .66$. Hypotheses one was therefore rejected. Students taught with the reflection instructional strategy achieved significantly higher than those taught by the conventional method. The pretest covariate was not significant, $F(1, 82) = 0.56$, $p = .455$.

Research Question 2: *What is the difference between the mean achievement scores of male and female students taught chemistry with the reflection instructional strategy?*

Table 6: Pretest and Posttest Achievement Scores of Male and Female Students in the Reflection Group

Gender	*N*	Pretest *M*	*SD*	Posttest *M*	*SD*	Mean gain
Male	25	18.48	1.04	39.20	1.52	20.72
Female	20	19.00	1.02	39.70	2.17	20.70
Difference		0.52		0.50		0.02

Male students in the reflection group scored 39.20 (*SD* = 1.52) at posttest and female students 39.70 (*SD* = 2.17). Female students started 0.52 points higher and finished 0.50 points higher, and the mean gains were practically the same (20.72 and 20.70).

Hypothesis Two: There is no significant difference in the mean achievement scores of male and female students taught chemistry using the reflection instructional strategy.

Table 7: *ANCOVA of Posttest Achievement Scores by Gender in the Reflection Group*

Source	Sum of squares	*df*	Mean square	*F*	*p*
Corrected model	3.196	2	1.598	0.46	.634
Pretest (covariate)	0.419	1	0.419	0.12	.730
Gender	3.150	1	3.150	0.91	.346
Error	145.781	42	3.471		
Corrected total	148.978	44			

With pretest scores controlled, gender had no significant effect on achievement, $F(1, 42) = 0.91$, $p = .346$, partial $\eta^2 = .02$. Hypotheses was therefore not rejected. Male and female students taught with the reflection strategy did not differ significantly in achievement.

DISCUSSION

Students taught with the reflection strategy scored higher than those taught by lecture at posttest, and their gain over the ten weeks was larger (20.71 against 15.40). This agrees with Agbasi and Okeke (2020) in chemistry, Awodun (2020) in physics, Okigbo and Chukwunyelu (2025) in mathematics and Ogbuanya and Owodunni (2015) in electronic works. It differs from Canses and Mehmet (2015), whose reflection group did not score significantly higher. That study used 42 pre-service teachers instead of secondary school students, and differences in participants, activities and duration may account for the different result.

The advantage may be due to what students did in the lessons. Each reflection lesson started with recall of earlier work, followed by problem attempts, sharing and defending answers, guided worksheets and notebook entries. In topics such as mole calculations, where errors often come from misreading how quantities relate, this routine gave students repeated chances to notice and correct mistakes before the test. The lecture class covered the same content and did classwork individually, but most of the reasoning was done by the teacher. This explanation is only a suggestion, because students' reflective processes were not measured.

The effect size is large (partial $\eta^2 = .66$) and scores within each group were close together. Only two schools took part, each taught by its own teacher, so part of the difference may come from school and teacher effects that the design could not separate from teaching method. The size of the difference should be read with this in mind.

Male and female students taught with the reflection strategy did not differ significantly in achievement. Their posttest means were 39.20 and 39.70 and their gains were 20.72 and 20.70. This agrees with Adigun et al. (2015) and Attah and Ita (2017), who found no significant gender effect in other subjects, and with Ogbuanya and Owodunni (2015), who found no interaction between technique and gender. It differs from the advantage for boys those authors found in electronic works trade. In the present study girls and boys were in the same classes, used the same worksheets and exchanged answers in the same way, which may have given both equal access to the activities.

The gender result should be read carefully. It rests on 25 boys and 20 girls and comes only from the reflection group. It shows that girls and boys did equally well when taught this way. It cannot show whether reflection helped boys and girls by the same amount relative to lecture, because gender was not analysed in the lecture group and the treatment-by-gender interaction was not tested.

CONCLUSION

In the two classes studied, SS II students taught chemistry with the reflection instructional strategy achieved significantly higher than those taught by lecture. Male and female students taught with the strategy achieved at a similar level and gained by almost the same amount. Chemistry teachers in Edo State secondary schools can try the strategy, and these results give no sign that it favours either sex.

RECOMMENDATIONS

1. Chemistry teachers in Edo State should use the reflection instructional strategy, particularly for calculation-based topics such as the mole concept and stoichiometry, with guided worksheets, reflection journals and structured peer discussion.
2. Teachers should organise mixed-sex groups and give male and female equal roles in reflection activities so that both continue to benefit.

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