



EFFECTS OF GUIDED DISCOVERY INSTRUCTIONAL STRATEGY ON STUDENTS' ACADEMIC ACHIEVEMENT IN ELECTROLYSIS

BY

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Abstract

This study examined the effect of guided discovery instructional strategy on Senior Secondary II students' academic achievement in electrolysis. It also investigated school type and its interaction with instructional method. A pretest-posttest non-equivalent control-group quasi-experimental design was adopted. The population comprised 4,393 Senior Secondary II science students in Ilaje Local Government Area, Ondo State, Nigeria. A sample of 120 chemistry students from four secondary schools was selected through multistage sampling. Data were collected using a 20-item Electrolysis Performance Test validated by specialists in chemistry education and measurement and evaluation. The instrument yielded a Kuder-Richardson Formula 20 reliability coefficient of .81. The intervention lasted six weeks. Three null hypotheses were tested using analysis of covariance at the .05 level, with pretest scores entered as the covariate. Results showed that guided discovery significantly improved achievement, $F(1, 117) = 49.398$, $p < .001$. School type had no significant effect, $F(1, 117) = 1.571$, $p = .213$, while the method-by-school-type interaction was not significant, $F(1, 115) = 1.829$, $p = .179$. The study concluded that guided discovery was more effective than the conventional method and produced comparable achievement gains across public and private schools.

Keywords: academic achievement; conventional method; electrolysis; guided discovery; school type

Introduction

Chemistry contributes to scientific literacy and provides foundational knowledge for health, engineering, agriculture, environmental management and other science-based fields. Electrolysis is an important aspect of senior secondary chemistry because it requires learners to connect observable laboratory events with particle-level processes and symbolic equations. To understand electrolysis meaningfully, students must coordinate ideas about ions, electrodes, electron transfer, oxidation-reduction reactions, electrical conductivity and the products formed at the electrodes.

Recent evidence shows that electrochemistry remains conceptually demanding for learners. Students may confuse the signs and functions of the anode and cathode, assume that electrons move through an electrolyte in the same way that they move through a metallic conductor, or fail to distinguish electrolytic cells from voltaic cells (Hadinugrahaningsih et al., 2022; Nakiboğlu et al., 2024). A

systematic review of chemistry misconceptions also shows that abstract chemical concepts are particularly vulnerable to fragmented understanding when students rely mainly on memorised rules (Suparman et al., 2024). In a West African Senior School Certificate Examination report, the West African Examinations Council noted that many candidates could not identify the products formed during the electrolysis of concentrated sodium chloride solution with graphite electrodes (West African Examinations Council [WAEC], 2020). These findings provide a clear basis for investigating instructional approaches that make students reason from evidence rather than merely recall completed explanations.

Guided discovery instructional strategy is a structured learner-centred approach in which the teacher presents carefully sequenced tasks, questions, materials and feedback that enable students to derive concepts and principles. The strategy differs from unguided discovery

because the teacher remains actively involved by directing attention, providing prompts, correcting unproductive paths and consolidating the scientific principle after exploration. Inquiry-oriented learning commonly proceeds through orientation, investigation, interpretation and conclusion, with guidance helping learners to connect each phase to the intended learning outcome (Pedaste et al., 2015). A meta-analysis further showed that guidance improves inquiry activities, task performance and learning outcomes (Lazonder & Harmsen, 2016). More recent synthesis also supports combining inquiry with explicit teacher direction rather than treating the two approaches as mutually exclusive (de Jong et al., 2023).

Electrolysis is suitable for guided discovery because its central relationships can be investigated through observable changes and then explained at the symbolic and particle levels. Learners can predict electrode products, observe colour or gas changes, trace ionic movement, identify oxidation and reduction sites, write half-equations and compare their predictions with evidence. Research on electrochemistry instruction indicates that structured visual and representational activities can improve conceptual understanding when students are required to generate, evaluate and revise explanations (Lin & Wu, 2021). Guided discovery therefore creates opportunities for students to link practical observations with the underlying electrochemical processes.

School type may also shape the conditions under which an instructional strategy is implemented. Public and private schools can differ in class size, laboratory access, availability of consumables, supervision and teacher support. These contextual differences do not constitute an instructional treatment, but they may influence students' learning opportunities and the consistency with which practical strategies are implemented. Nigeria's education sector analysis identifies continuing inequalities in educational resources and learning conditions (Federal Ministry of Education, 2022). However, recent Nigerian evidence from chemistry instruction found that students taught with a guided-inquiry strategy performed better than those taught through lecture, while achievement did not differ significantly between public and private schools (Musa et al., 2025). It is therefore

useful to distinguish the main effect of instructional method from the main effect of school type and from the interaction between the two.

The problem addressed in this study is the persistent difficulty students experience in electrolysis and the limited local evidence on whether guided discovery improves achievement consistently across public and private secondary schools in Ilaje Local Government Area. Although guided discovery has demonstrated promise in science education, its effectiveness must be established with context-specific evidence and interpreted without treating school type as an experimental treatment. The study therefore compared guided discovery with the conventional method and examined the main and interaction effects of instructional method and school type on Senior Secondary II students' academic achievement in electrolysis.

Purpose of the Study

The study determined the effect of guided discovery instructional strategy on Senior Secondary II students' academic achievement in electrolysis. It also examined whether achievement differed between students in public and private schools and whether the effect of instructional method varied according to school type.

The following null hypotheses were tested at the .05 level of significance:

1. There is no significant difference in the pretest–posttest achievement mean scores of students taught electrolysis using guided discovery instructional strategy and those taught using the conventional method.
2. There is no significant difference in the pretest–posttest achievement mean scores of students in public and private schools.
3. There is no significant interaction effect between instructional method and school type on students' achievement in electrolysis.

Literature Review

Guided discovery is an inductive instructional approach in which learners encounter a problem, pattern or set of observations before the teacher consolidates the formal principle. The approach is not equivalent to leaving students to discover complex scientific ideas without support. Instead, guidance is embedded in the selection of examples, questions, representations, feedback and the

sequence of learning activities. Pedaste et al. (2015) explained inquiry learning as a cyclical process involving orientation, conceptualisation, investigation, conclusion and discussion. Within guided discovery, the teacher uses these phases flexibly and provides enough structure to keep learners focused on the intended concept.

The quality of guidance is central to the effectiveness of discovery-oriented instruction. Lazonder and Harmsen (2016) found positive overall effects of guidance on learning activities, successful task performance and learning outcomes. De Jong et al. (2023) similarly argued that inquiry and direct instruction should be combined according to the learning objective, students' prior knowledge and the complexity of the domain. For electrolysis, this means that students may investigate electrode processes and interpret observations, while the teacher supplies prompts, checks misconceptions and explicitly consolidates accepted electrochemical explanations.

Electrolysis requires learners to integrate several representations. They must connect a visible change, such as gas evolution or metal deposition, with ion movement, electron transfer and half-equations. Nakiboğlu et al. (2024) found that senior high-school students from different national contexts shared weak understanding and common alternative conceptions concerning electrolysis, current flow and electrode polarity. Hadinugrahaningsih et al. (2022) also reported misconceptions in reduction-oxidation concepts, which are prerequisite knowledge for electrochemical cells. These findings indicate that effective electrolysis instruction should require students to explain the relationships among observations, particles and symbols rather than reproduce isolated rules.

Empirical studies provide support for guided forms of inquiry and discovery in science. Egbes and Ajaja (2023) reported that secondary school students taught biology through guided discovery achieved and retained more than students taught through lecture. In chemistry, Musa et al. (2025) found that guided inquiry improved students' performance in esterification relative to lecture instruction. Lin and Wu (2021) further demonstrated that structured visualisation activities could improve high-school students' electrochemistry understanding and learning

motivation. Although these studies differ in subject matter and setting, they support the principle that students learn complex science concepts more effectively when they actively investigate evidence under structured teacher guidance.

School type is a contextual variable rather than an experimental treatment. Public and private schools may provide different levels of facilities, staffing and instructional support, but such differences do not automatically produce achievement differences after students' initial scores and the instructional method are considered. Musa et al. (2025) found no significant achievement difference between public and private school students exposed to guided inquiry. The present study therefore tested school type as a main effect and also examined whether it moderated the effect of instructional method.

Methodology

The study adopted a pretest-posttest non-equivalent control-group quasi-experimental design. The population comprised 4,393 Senior Secondary II science students in co-educational secondary schools in Ilaje Local Government Area of Ondo State during the 2025/2026 academic session. A sample of 120 SSII chemistry students was selected from four schools through a multistage sampling procedure involving stratification by school type and random selection of participating schools. Four intact classes were used, and the sample represented guided discovery and conventional-method conditions across public and private schools.

Data were collected with the Electrolysis Performance Test (EPT), a researcher-developed 20-item multiple-choice test based on the electrolysis content prescribed for SSII chemistry. Specialists in chemistry education and measurement and evaluation reviewed the instrument for face and content validity. Because the items were scored dichotomously, internal consistency was estimated using Kuder-Richardson Formula 20, which produced a reliability coefficient of .81.

Permission to conduct the study was obtained from the participating schools. The EPT was administered as a pretest before the intervention. Treatment lasted six weeks, with one 80-minute lesson per week for each group. Students in the experimental condition learned through guided questions, cooperative tasks and hands-on electrolysis activities. Students in the control condition received

conventional teacher-centred instruction through explanation, note-taking and worked examples. Both groups covered the same electrolysis content and completed the EPT as a posttest after the intervention.

Analysis of covariance (ANCOVA) tested the three null hypotheses at the .05 significance level. Posttest achievement was the dependent variable, while pretest achievement was entered as the covariate to adjust for initial differences between the intact classes. The analyses examined the main effect of instructional method, the main effect of school type and the interaction between

instructional method and school type. Results are reported with F values, degrees of freedom, p values and model R^2 .

Results

Hypothesis One: There is no significant difference in the pretest–posttest achievement mean scores of students taught electrolysis using guided discovery instructional strategy and those taught using the conventional method.

Table 1: ANCOVA of the Difference in Students' Posttest Achievement in Electrolysis by Instructional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	477.006	2	238.503	98.710	.000
Intercept	1109.561	1	1109.561	459.219	.000
Pretest	274.991	1	274.991	113.812	.000
Method	119.355	1	119.355	49.398	.000
Error	282.694	117	2.416		
Total	15148.000	120			
Corrected Total	759.700	119			

Note. $R^2 = .628$; adjusted $R^2 = .622$.

Table 1 shows a significant main effect of instructional method on students' achievement in electrolysis, $F(1, 117) = 49.398$, $p < .001$. Since the p value is lower than .05, the null hypothesis was rejected. The adjusted posttest achievement of students taught through guided discovery was significantly

higher than that of students taught through the conventional method.

Hypothesis Two: There is no significant difference in the pretest–posttest achievement mean scores of students in public and private schools.

Table 2: ANCOVA of the Difference in Students' Posttest Achievement in Electrolysis by School Type

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	362.977	2	181.488	53.524	.000
Intercept	1070.158	1	1070.158	315.606	.000
Pretest	360.527	1	360.527	106.325	.000
School Type	5.326	1	5.326	1.571	.213
Error	396.723	117	3.391		
Total	15148.000	120			
Corrected Total	759.700	119			

Note. $R^2 = .478$; adjusted $R^2 = .469$.

Table 2 shows that the main effect of school type was not statistically significant, $F(1, 117) = 1.571$, $p = .213$. Since the p value is greater than .05, the null hypothesis was retained. Thus,

after controlling for pretest achievement, students' posttest achievement did not differ significantly between the public and private schools included in the study.

Hypothesis Three: There is no significant interaction effect between instructional method and school type on students' achievement in electrolysis.

Table 3: Two-Way ANCOVA of the Interaction between Instructional Method and School Type on Students' Achievement in Electrolysis

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	481.503	4	120.376	49.761	.000
Intercept	1100.195	1	1100.195	454.795	.000
Pretest	270.400	1	270.400	111.777	.000
Method	89.031	1	89.031	36.803	.000
School Type	.231	1	.231	.095	.758
Method $\times$ School Type	4.424	1	4.424	1.829	.179
Error	278.197	115	2.419		
Total	15148.000	120			
Corrected Total	759.700	119			

Note. $R^2 = .634$; adjusted $R^2 = .621$.

Table 3 shows that the interaction between instructional method and school type was not statistically significant, $F(1, 115) = 1.829$, $p = .179$. Since the p value is greater than .05, the null hypothesis was retained. It was therefore concluded that there was no significant interaction effect of instructional method on students' achievement in electrolysis based on school type.

Discussion

The first finding revealed a significant effect of instructional method on students' achievement in electrolysis, with students taught through guided discovery outperforming those taught through the conventional method. The finding suggests that structured investigation, teacher questioning, practical engagement and explanation helped students to develop a more coherent understanding of electrolysis. This interpretation is consistent with the evidence that inquiry is most effective when learners receive adequate guidance and when explicit explanation is integrated with investigation (de Jong et al., 2023; Lazonder & Harmsen, 2016). The result also agrees with Egbes and Ajaja (2023), who found higher achievement under guided discovery than lecture instruction, and with Musa et al. (2025), who reported an advantage for guided inquiry in chemistry. The benefit of guided discovery is especially relevant to electrolysis because the topic

requires students to coordinate macroscopic observations, particle movement and symbolic representations. During guided discovery lessons, students were not limited to receiving finished rules; they predicted products, examined evidence and related electrode changes to oxidation and reduction. This type of representational engagement is consistent with Lin and Wu's (2021) finding that structured visualisation and model revision can strengthen electrochemistry understanding. It also responds directly to the persistent misconceptions documented by Hadinugrahaningsih et al. (2022) and Nakiboğlu et al. (2024).

The second finding showed no statistically significant main effect of school type on students' achievement. This means that, after pretest achievement was controlled, the public and private school students included in the study did not differ significantly in posttest performance. The finding agrees with Musa et al. (2025), who reported no significant difference between public and private school students taught chemistry through guided inquiry. The result should not be interpreted as proof that public and private schools are identical in resources or organisation; rather, it indicates that school ownership did not independently account for a significant achievement difference in this sample.

The third finding revealed no significant interaction between instructional method and school type. Thus, the observed advantage of guided discovery did not vary significantly between the public and private schools included in the study. This finding supports the applicability of guided discovery across the two school types when the strategy is implemented with comparable content, lesson duration and instructional support. However, the absence of a significant interaction should be interpreted within the limits of the four participating schools and should not be generalised as evidence that school context can never influence implementation.

Conclusion

Guided discovery instructional strategy significantly improved Senior Secondary II students' academic achievement in electrolysis compared with the conventional method. School type did not significantly influence achievement, and the interaction between instructional method and school type was not significant. The study therefore concludes that guided discovery is an effective approach to teaching electrolysis and that its observed achievement advantage was consistent across the public and private schools included in the study.

Recommendations

1. Chemistry teachers should use structured guided discovery activities that combine prediction, practical investigation, questioning, evidence-based explanation and teacher-led consolidation when teaching electrolysis.
2. Teacher-training and professional-development programmes should include practical guidance on how to scaffold guided discovery lessons, manage cooperative laboratory activities and correct misconceptions during electrolysis instruction.
3. Public and private school authorities should provide the basic apparatus, electricity supply and consumable materials required for guided discovery activities in electrolysis.
4. Curriculum supervisors should monitor the quality of implementation in both public and private schools so that guided discovery is applied as a structured

strategy rather than as unguided experimentation.

5. Further studies should use larger samples, report adjusted group means and measure implementation fidelity, teacher characteristics and laboratory resources to clarify the conditions under which guided discovery produces the strongest achievement gains.

References

- de Jong, T., Lazonder, A. W., Chinn, C. A., Fischer, F., Gobert, J., Hmelo-Silver, C. E., Koedinger, K. R., Krajcik, J. S., Kyza, E. A., Linn, M. C., Pedaste, M., Scheiter, K., & Zacharia, Z. C. (2023). Let's talk evidence—The case for combining inquiry-based and direct instruction. *Educational Research Review*, 39, 100536. <https://doi.org/10.1016/j.edurev.2023.100536>
- Egbes, N. L., & Ajaja, O. P. (2023). Effects of guided discovery and problem-solving instructional strategies on achievement and retention of biology students in Delta Central Senatorial District, Nigeria. *European Journal of Education Studies*, 10(4), 353–372. <https://doi.org/10.46827/ejes.v10i4.4793>
- Federal Ministry of Education. (2022). Education sector analysis 2021. <https://education.gov.ng/education-sector-analysis-2021/>
- Hadinugrahaningsih, T., Rahmawati, Y., & Suryani, E. (2022). An analysis of preservice chemistry teachers' misconceptions of reduction-oxidation reaction concepts. *Journal of Technology and Science Education*, 12(2), 448–465. <https://doi.org/10.3926/jotse.1566>
- Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research*, 86(3), 681–718. <https://doi.org/10.3102/0034654315627366>
- Lin, C. Y., & Wu, H. K. (2021). Effects of different ways of using visualizations on high school students' electrochemistry conceptual understanding and motivation towards chemistry learning. *Chemistry Education Research and Practice*, 22(3),



- 786–801.
<https://doi.org/10.1039/D0RP00308E>
- Musa, A. A., Muhammad, B. A., & Bugaje, B. M. (2025). Effect of guided-inquiry-based instructional strategy on performance in esterification concept among secondary school students in Zaria Metropolis, Kaduna State. *Zamfara International Journal of Education*, 5(4), 152–158.
<https://doi.org/10.64348/zije.2025102>
- Nakiboğlu, C., Rahayu, S., Nakiboğlu, N., & Treagust, D. F. (2024). Exploring senior high-school students' understanding of electrochemical concepts: Patterns of thinking across Turkish and Indonesian contexts. *Chemistry Education Research and Practice*, 25(1), 42–61.
<https://doi.org/10.1039/D3RP00124E>
- Pedaste, M., Mdeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47–61.
<https://doi.org/10.1016/j.edurev.2015.02.003>
- Suparman, A. R., Rohaeti, E., & Wening, S. (2024). Student misconception in chemistry: A systematic literature review. *Pegem Journal of Education and Instruction*, 14(2), 238–252.
<https://doi.org/10.47750/pegegog.14.02.28>
- West African Examinations Council. (2020). Chemistry Paper 2, WASSCE for Private Candidates (First Series): Question 1 observation.
<https://www.waeconline.org.ng/e-learning/Chemistry/chem230aq1.html>