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# GUIDED INQUIRY TEACHING STRATEGY AND STUDENTS' PERFORMANCE IN REDOX REACTION IN RIVERS STATE

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**Abstract**
The study investigated the effect of guided inquiry on students' performance in redox reactions in senior secondary schools in Obio/Akpor Local Government Area in Rivers State, Nigeria. The study used a non-equivalent group pre-test-post-test quasi-experimental design. The study was led by three (3) research questions and three (3) null hypotheses. 11,920 SSII Science students make up the study's population, which is made up of 5,024 male and 6,896 female students. A total of 132 SS2 pupils from three public senior secondary schools in the Obio-Akpor Local Government Area were included in the sample. They were in their complete classes. Three public schools were chosen, and intact classrooms from each of those schools were also chosen using purposeful sample procedures. The Chemistry Performance Test on Redox Reaction and Mathematics Ability Test, two self-created validated instruments for data collection that were used for the study, had reliability coefficients of 0.88 and 0.76, respectively. The questions were answered using the mean and standard deviation, and the hypotheses were tested using Analysis of Covariance (ANCOVA) at the 0.05 level of significance. The findings indicated that guided inquiry improved student performance more effectively than the lecture method. The study's findings also showed that there were notable differences in the pupils' performance when it came to directed inquiry. In the redox reaction, the male students outperformed the female pupils. Regarding student achievement, there is no discernible joint interplay between strategy and mathematical prowess. The post hoc analysis showed that the significant difference found in the strategy concerning performance was credited to guided inquiry. The study recommended that chemistry teachers should be encouraged to use guided inquiry and virtual laboratory teaching strategies while teaching chemistry.

**Keywords**: Guided Inquiry Teaching Strategy, Lecture Method, Performance, Redox Reaction, Ability.

## Introduction

This study uses the social constructivism theory (Vygotsky, 1978) as its theoretical foundation. Children were active contributors to the creation of knowledge, according to Vygotsky. According to constructivism theory, teachers must be able to instruct students to study in groups both during class discussions and practical exercises in the lab or online. Dagar and Yadav's (2016) argument that students must create their knowledge both individually and collectively supports this. The development of knowledge can be impacted by social interaction (Wink, 2006). According to Ningsih and Said (2017), the guided inquiry learning paradigm involves several processes, including problem-solving, experiment planning, experiment execution, data collection, data analysis, and concluding. The guided inquiry learning model, according to Alberta, consists of the following six syntaxes:

1) Planning. Teachers provide problems that are relevant to daily life in the first phase. In addition, professors show pupils how to approach problems and solve them. As a result, they can conduct experiments to uncover the answer.
2) Retrieving. Students' task in this section is to locate and gather information on the issues raised by professors from various sources.
3) Processing information. Students perform experiments to test and validate their hypotheses. In this step, they analyze as well.
4) Making/Creating information. Students conclude their previous works in this syntax.

5) Communicating/sharing information. Students show their conclusion by discussion in class, while teachers give comments on this topic and provide reinforcement and straighten faults.
6) Evaluating. In the final syntax, professors commend each group that delivered a presentation before assigning them individual tasks related to the studied contents. The teacher poses difficulties for the students to solve, involving them both physically and mentally.

According to Chourasiya (2022), the lecture technique is a type of classroom instruction in which teachers explain academic principles and lesson plans to their students. simply refers to the "Lecture Method," or lecturing as a teaching method. It is the most practical and affordable approach that may be used for scientific instruction in our schools. Except for the chalkboard, it hardly ever necessitates the use of any scientific instruments, experiments, or support materials. It is known as the "chalk and talk method" for this reason. However, it helps immensely in quickly completing the course with the little time and scarce resources available.

The lecture mode of instruction is the one that has been used in educational institutions the longest. This kind of instruction is a one-way information channel. In this teaching technique, the students only need to listen and occasionally take notes during the lecture to organize and combine the material. Getting the pupils' attention in the classroom is one of the issues with this strategy. The fact that many of the class's students are unable to grasp the concept is another major issue. The way we teach has a big impact on what we learn.

According to Usselman et al. (2021), chemistry is the branch of science that studies the characteristics, make-up, and structure of substances (specified as elements and compounds), the changes they go through, and the energy that is used or consumed during these changes. The economic impact of chemistry is significant. It is crucial in supplying people with the food, medical supplies, and other materials they need to live better lives.

The major goals of teaching chemistry in secondary schools are to allow the students to advance their knowledge and expertise in chemical science and to project their educational efforts in a way that will benefit both them and society at large. According to Avwiri (2011), a teacher's method can either encourage or prevent learning. As a subject that most students find intimidating, chemistry teachers must employ effective methods to pique students' interests and support the development of positive attitudes for successful learning outcomes.

A chemical reaction known as an oxidation-reduction (redox) reaction includes the exchange of electrons between two substances. Any chemical reaction in which the oxidation number of a molecule, atom, or ion changes by acquiring or losing an electron is referred to as an oxidation-reduction reaction. Some of the fundamental processes of life, such as photosynthesis, respiration, combustion, and corrosion or rusting, depend on redox reactions. (Redox Chemistry, 2020).

Student academic success, according to Narad and Abdullah (2016), is the focal point around which the whole educational system revolves. Any educational institution's success or failure is evaluated based on the student's academic progress.

Academic performance is the knowledge acquired and measured by the grades given by the teacher. Academic performance in the context of education refers to the educational goal that must be met by a student, instructor, or institution during a specific period. The goal may vary from one person or institution to another and is assessed through exams or ongoing evaluations. The result of education is academic performance, which measures how well a student, instructor, or institution has completed their educational objectives. (Narad & Abdullah, 2016).

Chemistry classroom activities are still dominated by teacher-centred methods, like lectures and teacher demonstrations, which are ineffective in promoting science learning at the primary and secondary school levels, according to research reports on the status of teaching chemistry education in schools in Nigeria. As a result, students in Nigeria consistently do poorly on chemistry examinations, both internal and external. Despite the importance of Redox Reaction in our everyday life, according to the WEAC chief examiners report for 2017 -2019, Redox Reaction is one of the concepts in which students exhibited weaknesses such as a lack of knowledge of the chemical concept, unable to write a simple half equation, unable to recognize Redox Reaction equation, the wrong use of symbols to represent ions, poor knowledge of mole concept and arithmetic errors. Students often find it


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difficult to distinguish between the redox process and other physical and chemical reactions in chemistry. The non-cre–concrete nature of this topic involves the gaining and the loosing of electrons as a result of the increase and the decrease in the oxidation state of the elements has made it difficult for students to comprehend. The mathematical inclination in redox reaction which is based on the knowledge of the oxidation number to identify the oxidizing and reducing agent is a hard nut to crack and also to balance redox equations. Could this student's difficulty in Redox Reaction be due to the teaching strategy that is used to teach Redox Reaction? Could it be due to the poor mathematical background of the students? Based on the gaps identified, the researcher intends to investigate using suitable innovative /instructional strategies that will hopefully enhance performance in Redox Reaction in chemistry.

**Aim and Objectives**

The study's goal was to find out how students' interest in and performance in chemistry were affected by guided inquiry and virtual laboratory teaching strategies.

Specifically, the objectives of the study are to:

1) Examine how teaching techniques, such as the guided inquiry teaching strategy, affect students' performance in redox reactions.
2) Examine the differences in students' success in redox reactions between those with high, average, and low mathematical aptitudes.
3) Ascertain how students' success in redox reactions is affected by their mathematical aptitude and instructional methodologies.

**Research questions**

1) What is the difference in the mean performance score among students taught Redox Reaction using GITS and those taught using LM?
2) What is the difference in the mean performance score among students of different mathematical abilities? (High, average and low abilities).
3) What is the joint effect of teaching strategies, and mathematical ability on students' performance in Redox reaction?

**Hypotheses**

The following hypotheses were tested at a 0.05 level of significance:

$H_{01}$: There is no significant difference between students taught using GITS and those taught using LM in their performance in Redox Reaction.

$H_{02}$: There is no significant difference among students of different mathematical abilities concerning their performance in Redox Reaction.

$H_{03}$: There is no significant joint effect of teaching strategies, gender and mathematical ability on students' performance in Redox reaction.

**Methodology**

This study used a quasi-experimental research design to carry out the examination. When control and modification of pertinent variables are allowed, the quasi-experimental pre-test and post-test, non-equivalent group design are suited for simulating approximately the conditions of an actual experiment. The study was conducted in Rivers State's Obio/Akpor Local Government Area Rivers State. All Senior Secondary II (SSII) Chemistry students from all public secondary schools in Obio-Akpor Local Government Area, totalling 11,920 SSII Science students in Obio/Akpor Local Government Area in Rivers State, make up the study's population. There are 5,024 male and 6,896 female students in this population.

This study's sample size was 85 SSII chemistry students, 33 of whom were male and 52 of whom were female, enrolled in their intact classrooms. Out of the twenty-one (21) public schools in the Obio/Akpor Local Government Area, three were purposefully chosen. The study included a sample size of 132 pupils. The three schools in Rivers State's Obio/Apkor local government area were chosen based on the following criteria.

I. They have qualified Chemistry teachers.

II. They are mixed schools.
III. They have a qualified number of Chemistry students.
IV. A well-equipped computer laboratory and artificial supply of electricity.
V. Sizeable classroom and conducive learning environment.
VI. Access to instructional materials for teaching and learning of chemistry.

Following that, two out of three schools were chosen at random and placed in Experimental Groups 1 and 2, respectively, while the third school was placed in the Control group. From each of the three schools, one complete class was picked.

For data collection, the researcher designed two instruments: the Chemistry Performance Test on Redox Reaction (CPTRR) and the Mathematics Ability Test (MAT). The (CPTRR), a 30-question multiple-choice objective test with questions derived from the subject of redox reaction, was designed to gauge students' proficiency in the subject. Each test question on the instrument contained four possible answers: A, B, C, and D. Only one of these answers served as the key, while the other three served as distractions. The CPTRR question related to the redox reaction lesson that was taught. The students responded by checking the appropriate option after the instrument's introduction and teaching. Each correctly answered question received one mark, while the erroneous response received a score of zero. The CPTRR received a total of 30 points. The tests were used as pre-and post-tests to gauge the performance of the students. To determine the pupils' baseline level of mathematical proficiency, a Mathematical Ability Test (MAT) was given to them. A set of 30 multiple-choice questions was utilized to gauge students' mathematical proficiency. These questions encompassed themes in mathematics such as algebra and linear inequality, both of which are connected to the mathematical idea of the redox reaction. The researcher's two supervisors, an expert in science education and two experts in measurement and evaluation from the University of Port Harcourt, verified the CPTRR and MAT instruments. The terms "face validity" and "content validity" refer to the degree to which a test appears to measure what it purports to measure based on face value and the degree to which the test's items are fairly representative of the full domain it seeks to measure, respectively. Their recommendations and advice were followed, and the necessary changes were made.

A pilot test was done with 30 students from a school that was not included in the study but that met the criteria for being chosen for the study and was located in the same Local Government Area as the sampled schools to assess the reliability of the instrument. Thirty (30) pupils in SS2 Chemistry were tested using the instruments Chemistry Performance Test on Redox Reaction (CPTRR) and Mathematics Ability Test (MAT). On the spot, filled-out copies of the reliability test instruments were retrieved. The script was annotated and noted. Using Kuder Richardson 21 (KR-21), the reliability coefficient for CPTRR and MAT was calculated. The dependability indices were 0.88 and 0.79, respectively. The treatment was administered at several schools by chemistry teachers who had received training from the researcher. Before the therapy session, all of the sampled students took a CPTRR and MAT pre-test. A post-test of the tool (CPTRR) was given to determine the academic achievement of the sampled pupils three weeks after the start of treatment. The study scores obtained from CPTRR and MAT constituted the data for this study. Mean scores and standard deviations were utilized to respond to the research questions, and an Analysis of Covariance (ANCOVA) was performed to test the null hypotheses at the 0.05 level of significance. In the post hoc Analysis, Fisher's least significant difference test was employed. The students were divided into three groups based on their MAT scores: those with high, average, and poor mathematical aptitude (high MA, average MA, low MA). The criteria for the ability level were as follows: high ability was defined as 25–30, ordinary ability as 15–24, and low ability as 0-14.


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## Results

**Research question 1:** What is the difference in the mean performance score among students taught Redox Reaction using GITS and those taught using LM?

**Table 1: Mean and standard deviation of student performance score classified by Strategies**

| STRATEGY | | CPTRR PRETEST MEAN | CPTRR POSTTEST MEAN | CPTRR MEAN GAIN |
|---|---|---|---|---|
| GUIDED INQUIRY TEACHING STRATEGY | Mean | 7.795 | 14.077 | 6.282 |
| | N | 39 | 39 | 39 |
| | Std. Deviation | 2.648 | 4.0418 | 4.501 |
| LECTURE METHOD | Mean | 6.468 | 7.894 | 1.426 |
| | N | 47 | 47 | 47 |
| | Std. Deviation | 2.3299 | 3.150 | 3.328 |

Table 1 shows a mean performance gain of a mean performance gain of 6.282 for students taught Redox Reaction with GITS and a mean performance gain of 1.426 for students taught Redox Reaction with LM. This indicates that students taught Redox Reaction using GITS had the highest mean performance gain. In other words, GITS enhanced students' performance better.

**Research question 2:** What is the difference in the mean performance score among students of different mathematical abilities? (High, average and low abilities).

**Table 2: The mean gain and standard deviation of student's mathematical abilities classified by performance**

| MATH ABILITY | | CPTRR PRETEST MEAN | CPTRR POSTTEST MEAN | CPTRR MEAN GAIN |
|---|---|---|---|---|
| HIGH | Mean | 7.608 | 13.956 | 5.565 |
| | N | 23 | 23 | 23 |
| | Std. Deviation | 3.158 | 4.139 | 4.794 |
| AVERAGE | Mean | 7.042 | 9.978 | 2.936 |
| | N | 47 | 47 | 47 |
| | Std. Deviation | 2.340 | 4.321 | 4.234 |
| LOW | Mean | 6.375 | 8.125 | 1.750 |
| | N | 16 | 16 | 16 |
| | Std. Deviation | 2.125 | 4.333 | 3.642 |

Table 2 shows that the mean gain of the performance of students with high mathematical ability is 5.565, the mean gain of the performance of students with average mathematical ability is 2.936, and the mean gain of the performance of the students with low mathematical ability is 1.750. Thus, students with high mathematical ability had the highest mean gain. In other words, students with high mathematical ability gained the most, followed by the students with average mathematical ability


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**Research question 3:** What is the joint effect of teaching strategies, gender and mathematical ability on students' performance in Redox reaction?

**Table 3: Mean and standard deviation of student performance classified by strategies, gender and mathematical ability.**

| STRATEGY | MATH ABILITY | | CPTRR PRETEST MEAN | CPTRR POSTTEST MEAN | CPTRR MEAN GAIN |
|---|---|---|---|---|---|
| GUIDED INQUIRY TEACHING STRATEGY | HIGH | Mean | 8.388 | 15.222 | 5.833 |
| | | N | 18 | 18 | 18 |
| | | Std. Deviation | 2.831 | 3.750 | 5.193 |
| | AVERAGE | Mean | 7.368 | 13.105 | 5.736 |
| | | N | 19 | 19 | 19 |
| | | Std. Deviation | 2.543 | 4.121 | 3.870 |
| | LOW | Mean | 6.500 | 13.000 | 6.500 |
| | | N | 2 | 2 | 2 |
| | | Std. Deviation | 0.707 | 5.656 | 6.363 |
| LECTURE METHOD | HIGH | Mean | 4.800 | 9.400 | 4.600 |
| | | N | 5 | 5 | 5 |
| | | Std. Deviation | 2.863 | 1.140 | 3.209 |
| | AVERAGE | Mean | 6.821 | 7.857 | 1.035 |
| | | N | 28 | 28 | 28 |
| | | Std. Deviation | 2.211 | 2.990 | 3.360 |
| | LOW | Mean | 6.357 | 7.428 | 1.071 |
| | | N | 14 | 14 | 14 |
| | | Std. Deviation | 2.273 | 3.877 | 2.867 |

Furthermore, Table 3 also shows that students taught Redox Reaction with GITS had a high mathematical ability mean gain of 5.833, average mathematical ability mean gain of 4.200 and low mathematical ability mean gain of 6.500. Table 3 further shows that the students taught Redox Reaction with lecture method had a mean gain of 4.600, 1.035 and 1.071 for high, average and low mathematical ability. This indicates that students taught Redox Reaction using the Guided Inquiry Teaching Strategy with low mathematical ability had a higher mean gain of 6,500.

**Hypothesis 1:** There is no significant difference between students taught using GITS and those taught using LM in their performance in Redox Reaction.

**Table 4: Summary of Analysis of Covariance of student's performance classified by strategy using pretest as a covariate.**

**Tests of Between-Subjects Effects**

Dependent Variable: CPTRR POSTTEST

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 991.582[a] | 2 | 495.791 | 45.695 | 0.000 |
| Intercept | 420.843 | 1 | 420.843 | 38.787 | 0.000 |
| CPTRR_PRETEST | 176.679 | 1 | 176.679 | 16.284 | 0.000 |
| STRATEGY | 580.889 | 1 | 580.889 | 53.538 | 0.000 |
| Error | 900.558 | 83 | 10.850 | | |
| Total | 11734.000 | 86 | | | |
| Corrected Total | 1892.140 | 85 | | | |

a. R Squared =0 .524 (Adjusted R Squared =0 .513)

Table 4. Shows $F_{(1, 83)} = 53.538$, p= 0.000 ($p<0.05$) for strategy. The null hypothesis is therefore rejected. This indicates that there is a significant difference between students taught using GITS and those taught using LM concerning performance.

**Hypothesis 2:** There is no significant difference among students of different mathematical abilities concerning their performance in Redox Reaction.

**Table 6: Analysis of covariance among students with different mathematical abilities classified by performance, using pretest as a covariate.**

**Tests of Between-Subjects Effects**

Dependent Variable: CPTRR POSTTEST

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 681.550[a] | 3 | 227.183 | 15.388 | 0.000 |
| Intercept | 276.754 | 1 | 276.754 | 18.746 | 0.000 |
| CPTRR_PRETEST | 307.096 | 1 | 307.096 | 20.801 | 0.000 |
| MATH_ABILITY | 270.858 | 2 | 135.429 | 9.173 | 0.000 |
| Error | 1210.589 | 82 | 14.763 | | |
| Total | 11734.000 | 86 | | | |
| Corrected Total | 1892.140 | 85 | | | |

a. R Squared = 0.360 (Adjusted R Squared =0 .337)

Table 6 shows $F_{(2, 82)} = 9.173$, $p = 0.000$ ($p < 0.05$) for mathematical ability. The null hypothesis is thereby rejected, which indicates that there is a significant difference among students with different mathematical abilities concerning their performance in Redox Reaction.

**Table 7: Post HOC Analysis**

**Pairwise Comparisons**

Dependent Variable: CPTRR POSTTEST

| (I) MATH ABILITY | (J) MATH ABILITY | Mean Difference (I-J) | Std. Error | Sig. [b] | 95% Confidence Interval for Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| HIGH | AVERAGE | 3.551* | .982 | .001 | 1.597 | 5.504 |
| | LOW | 4.900* | 1.267 | .000 | 2.379 | 7.422 |
| AVERAGE | HIGH | -3.551* | .982 | .001 | -5.504 | -1.597 |
| | LOW | 1.350 | 1.118 | .231 | -.873 | 3.573 |
| LOW | HIGH | -4.900* | 1.267 | .000 | -7.422 | -2.379 |
| | AVERAGE | -1.350 | 1.118 | .231 | -3.573 | .873 |

Based on estimated marginal means

*. The mean difference is significant at the 0.05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

From the Post Hoc analysis in Table 7, the students with high mathematical ability contributed most to the significant difference among students of different mathematical abilities concerning performance. In other words, students with high mathematics ability had the best performance in Redox Reaction.

**Hypothesis 3:** There is no significant joint effect of teaching strategies and mathematical ability on students' performance in Redox reaction.

**Table 8: Summary of the analysis of covariance of the joint effect of teaching strategy and mathematical ability on student's performance in Redox Reaction. Using pretest as a covariate.**

**Tests of Between-Subjects Effects**

Dependent Variable: CPTRR POSTTEST

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 1047.967[a] | 6 | 174.661 | 16.345 | 0.000 |
| Intercept | 412.322 | 1 | 412.322 | 38.586 | 0.000 |
| CPTRR_PRETEST | 174.785 | 1 | 174.785 | 16.357 | 0.000 |
| STRATEGY | 207.835 | 1 | 207.835 | 19.450 | 0.000 |
| MATH_ABILITY | 53.613 | 2 | 26.807 | 2.509 | 0.088 |
| STRATEGY * MATH ABILITY | 5.475 | 2 | 2.737 | 0.256 | 0.775 |
| Error | 844.172 | 79 | 10.686 | | |
| Total | 11734.000 | 86 | | | |
| Corrected Total | 1892.140 | 85 | | | |

a. R Squared = 0.554 (Adjusted R Squared = 0.520)

Table 8 shows $F_{(2, 79)} = 0,256$, $p = 0.775$ ($p > 0.05$). The null hypothesis is thereby retained indicating that there is no significant joint effect of teaching strategies and mathematical ability on students' performance in Redox Reaction.

## Discussion

### Teaching Strategy on Students' Performance

In the findings of this study, the guided inquiry teaching strategy was more effective in enhancing the performance of students, followed by the lecture method. The two teaching strategies enhanced the performance of students but guided inquiry had the highest effect on their performance. This implies that exposing students to various teaching strategies employed in this can improve the performance of students, but the extent of the improvement differs concerning teaching strategies. The study also revealed that there was a significant difference in the student's performance in Redox Reaction concerning strategies. The post hoc analysis further pointed out that guided inquiry teaching strategy had the highest effect among the teaching strategies employed in this study. Ogochukwe and Stephen (2022) reported that the guided inquiry teaching strategy enhanced students' performance better than the lecture method as well as the studies of Ningsih and Said (2017).

### Influence of Mathematical Ability on Students' Performance.

The findings of the study revealed that the students with high mathematical ability had the highest performance among students of different mathematical abilities in Redox Reaction, followed by students with average mathematical ability, then the students with low mathematical ability. The study also shows that there was a significant difference among students with different mathematical abilities concerning performance. The post hoc analysis also indicated that the students with high mathematical ability contributed most to the significant difference.

The findings of the study may be because the students with high mathematical ability are knowledgeable in mathematics and also grounded in linear equations and algebra which are the aspects of mathematics that were relevant to Redox Reaction which was employed in this study. This is in agreement with the findings of Okey and Charles-Ogan (2015) who stated that students with high mathematical ability have greater mean percentage gain.

### Interactive joint effect on teaching strategies and mathematical abilities on students' performance.

The second-order interaction effect revealed that there was no significant joint interaction between strategy and mathematics ability concerning students' performance in a redox reaction. These findings are in agreement with the findings of Ajayi and Ogbeba (2017) who pointed out that there was no significant joint effect of methods on students' performance. The post hoc analysis also revealed that guided inquiry teaching strategy made a significant difference in the instructional strategy, this also confirms the findings of Obafemi and Ogunkenule (2013) who reported that there was a significant difference in the mathematics abilities of students in their performance in sound waves.

**Conclusion**

The students had a better performance in Redox reaction using a guided inquiry teaching strategy. The student with high mathematical ability had the highest performance among students of different mathematical abilities in Redox Reaction.

**Recommendations**

1) In-service teachers should adopt the Guided Inquiry Learning Strategy which will enhance collaboration and teamwork the students would benefit greatly as it allows for reflection of ideas in order the build knowledge, comprehension and interpretation of concepts in chemistry.

2) Policymakers, school administrators and curriculum planners should consider guided inquiry teaching strategy in the planning, designing and reviewing of senior secondary school chemistry curriculum, especially in the sub-topics like redox reaction and electrolysis.

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