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Advance Organisers and Secondary School Students' Performance in Redox Reactions

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ABSTRACT

Students' performance in chemistry examinations in Nigerian secondary schools is consistently low. Factors attributed to students' low performance include students' interest in the subject, abstract and complex nature of the concepts, and dominant use of teacher-centered methods. Thus, the need for a novel strategy that has the potential to improve students' interest and present chemistry concepts more explicitly. This study aimed to examine the use of a method that incorporated advance organizers in teaching the redox reaction concept at the secondary school level. The study adopted a quasi-experimental design with pre and post-test control groups. The study targeted a population of 11,560 secondary school students in the Dutsin-Ma Educational zone, from which a sample of 138 form five science students were selected using a stratified sampling technique and randomly assigned into experimental and control groups. Data was collected using Redox Reaction Performance Test (RRPT) before and after the treatment that lasted eight weeks. The data was analyzed using means, standard deviations, and t-tests. Findings show that the method incorporated with advance organizers significantly affects the learning of redox reactions. Students in the experimental group achieved higher scores than those in the control group and there was no significant difference in performance between male and female in the experimental group. Thus, chemistry teachers and other stakeholders in science education were encouraged to adopt and strengthen the use of advance organizers in teaching science subjects in general and chemistry in particular.

Contribution/Originality: This study is among the few researches that examined the impact of advance organiser usage on students' performance in redox reaction among

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secondary in Katsina State Nigeria. Findings also indicated advanced organiser as gender friendly since no significant difference in performance between male and female.

1. Introduction

Secondary education is a step in Nigeria's educational ladder. It is segmented into two sections as in the National Policy on Education (Federal Republic of Nigeria, 2014), the first three years as part of the nine years of junior secondary education called the Basic level and the other three known as Senior Secondary education. The students at the secondary education level constitute the subject of this study. Bichi, Hafiz and Abdullahi (2017) views the secondary school level as pivotal to Nigeria's skill training. Agricultural Science, Biology, Chemistry, Mathematics, English language, and Physics are the science subjects offered at this level.

Chemistry is a pre-requisite subject taught at the senior secondary education level that students must pass to qualify for admission to pursue science-based programs, such as agricultural science and medicine in Higher Institutions (UTME, 2021). Thus, chemistry is a core subject since a good knowledge of chemistry is necessary to become a professional in any science and technology-related discipline. The importance of chemistry in technological development and its central role in other sciences is in almost every human endeavor. For example, Johnstone (2006) stated that the production and invention of materials and instruments that better the lives and explained the processes of nature happenings in the environment relied on chemistry knowledge. Similarly, Onwukpa and Nweke (2000), Sabitu and Francis (2016), Santos-Díaz, and Towns (2020) opined that learning chemistry was imperative in every society if the citizens cope with the fast-changing development in science and technology.

Though the concept of redox reaction in chemistry is abstract and found to be difficult, it's also an important concept and core for understanding many natural phenomena such as photosynthesis, rusting of iron, and respiration, among others. However, studies revealed that learning the concept by rote does not incorporate into the learner's cognitive structure (Obomanu & Ekenobi, 2011; Sabitu & Francis, 2016). These authors reported that oxidation-reduction or redox reaction is a core concept for learning chemical and biochemical systems in the senior secondary school chemistry curriculum. Redox reaction involves two opposing processes that at the same time and complement one another. It is an electron bookkeeping process, the transfer of electrons from one specie (the reducing agent) to another (the oxidizing agent), leading to changes in the electrical charges of the species involved. Thus, it provides a framework for explaining chemical properties and similarities.

According to reports, redox reactions present students with distinct challenges (Udo, 2011; Treagust, Mthembu & Chandrasegaran, 2014; Springer et al., 2021). For example, chief examiners' annual reports of National Examination Council (NECO) in chemistry noted that redox reaction questions were not a popular choice among chemistry students, and those who attempted them did poorly (NECO, 2020). Thus, this could have had a substantial role in the students' poor chemistry results.

Similarly, chemistry students have been intellectually deficient due to the lack of cognitive knowledge and structure to cope with the conceptual demands of learning redox reactions that have been abstract and difficult for both students and teachers (Jin,

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Rodriguez, Shah & Rushton, 2020). In his earlier study, Tagbo (2014) noted that the difficulties in learning some concepts are so stable and coherently internalized. Thus, their teaching can be through conventional instruction. This validated Trevors, Duffy, and Azevedo's (2014) point of view, which underlined the importance of scaffolding education, which builds on students' prior or existing knowledge to help them understand abstract concepts. However, there is a link between instructional practices and student accomplishment. Thus, more empirical research is needed. Therefore, more student-centered and novel strategies like the advanced organizer strategy are necessary for explicitly explaining abstract concepts and ensuring that specific parts of those concepts are meaningfully understood. The current study addresses this gap by introducing an advanced organizer into redox reaction instruction and broadening prior studies' results measures to incorporate resources to students as advancements to the lesson.

Ausubel's (1960) cognitive theory of learning explained the concept of the advanced organizer. The cognitivist were curious about what goes on in the student's minds when they learn. They think that students actively analyze information and that learning occurs due to their ability to organize, store, and then establish connections between information by comparing it to prior knowledge, schema, and texts. Ausubel (1960) believes that an essential predictor of learning is what the learner already knows. This notion is referred to as "schema theory" by Ping (2006), and it refered to a circumstance in which the student lament his previous experience with the new material to understand it. She went on to say that an aural presentation doesn't have meaning until it gives learners hints on how to decipher the message using their prior knowledge. This indicates how students incorporate the new information from the text into their pre-listening schema, i.e., background knowledge and global understanding. Therefore, with the aid of a variety of teaching materials, schemas have an impact on general information recognition and storage.

The goal of the present study is to examine whether adding advance organizers to the strategy in teaching redox reaction can have an impact on student performance. The research questions raised were:

i. Do students exposed to advance organizers in learning redox reactions perform differently in performances than students learning with conventional teaching methods?
ii. What is the difference in the mean achievement scores of male and female students taught the redox reaction concept using advance organizers?

2. Method

The study used a quasi-experimental research approach, with pre-test and post-test control groups. The student's performance in redox reaction was measured using the redox reaction performance test (RRPT) before and after treatment in both the experimental and control groups. Treatment was for eight weeks incorporating advanced organizers in teaching redox reaction in an experimental group. The students in the experimental and control groups were given a post-test at the end of the treatment period to see if variations existed in performance.

The two schools were selected and assigned to experimental and control groups from the list of schools in the Dutsin-Ma Education Zone using a stratified sampling technique. The sample of the study was from intact classes from the two schools. Sample size according to Omona (2013), at least 30 cases are required in each group for experimental research.

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In this study, the number of students in the sample size was 138. The number of students in the experimental group was 60 and 78 in the control group, respectively.

The Redox Reactions Performance Test (RRPT) was adopted from Sabitu (2015) and used to assess students' understanding of redox reaction topics in chemistry. This test items covered over the eight weeks of study on the redox reaction concept. The contents examined include oxidation, reduction, and balancing of redox equations; the test consists of 20 items for a total score of 40 points. The items assessed redox knowledge, comprehension, application, and analysis. Three specialists from the Department of Science Education at Federal University Dutsin-Ma assisted the researchers in determining the test's validity. The instrument reliability coefficient of 0.86 was determined through pilot testing using a test-retest and Cronbach's alpha methods. As a result, the test was deemed appropriate (Wallen & Fraenkel, 2013). This test was administered as a pre-test, restructured, and given as a post-test after the eight-week intervention. Means and standard deviations were the tools to answer the research questions and t-tests to compare the pre-test and post-test mean scores to test the hypothesis. Threats to validity such as pre-test and history effect are reduced by selecting schools in the same education zone and under the supervision of the same board, having two groups at a distance, and restructuring the items of the pre-test question before the post-test (Wallen & Fraenkel, 2013). In addition, threat due to interaction was avoided by drawing the subjects into experimental and control groups from different schools that were geographically away.

3. Findings

Impact advance organizers usage and students performance in learning redox reactions in experimental and control groups was presented in Table 1 as follows:

Table 1: Independent t-test Statistics on Difference in the Mean Performance Scores of the Experimental and Control Groups

Groups	N	Mean	Std	Mean diff	df	t-value	p	Remark
Experimental	60	23.74	4.55	3.91	136	4.26	0.001	Significant
Control	78	19.82	3.38					

P < 0.05, t value > 4.26 at df = 136

Table 1 shows that the mean performance scores of students taught redox reaction concepts using an advanced organizer and those taught using the conventional method are significantly different. Therefore, the p-value of 0.001 for the t-value of 4.26 is less than the alpha level of 0.05 for df = 136. The difference in mean performance scores between the experimental and control groups is statistically significant in favor of the experimental group, indicating that teaching using advanced organizers is an alternative for improving students' performance in redox reaction than the conventional method alone. Therefore, the result of the independent t-test analyses supported the idea that including advanced organizers in the classroom instructions improved students' performance in redox reactions. In terms of performance, there were statistically significant variations in scores before and after the intervention, indicating that the use of advanced organizers in teaching redox reactions has significantly impacted student's performance.

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The differences in the mean achievement scores of male and female students taught the redox reaction concept using advance organizers were presented in Table 2 as follows:

Table 2: Independent t-test Statistics on Difference in the Mean Performance Scores of Male and Female Students in the Experimental Group Only

Gender	N	Mean	STD	Mean diff	Df	t- value	P	Remark
Male	26	24.25	4.88	0.08	59	0.74	0.46	Not Significant
Female	34	24.33	4.18					

P > 0.05, at df 59

Table 2 reveal mean performance scores of 24.25 and 24.33 for male and female students, respectively. The p-value of 0.46 is higher than the alpha threshold of 0.05. Showed that the difference in the performance scores of male and female students in the experimental group was not significantly different. Thus, teaching redox reaction using advanced organizers has no discernible differences in the learning effects between male and female students.

4. Conclusion and Recommendation

Overall the data showed that including advanced organizers in instructional strategies improved students' redox reaction performance. The research adds to the body of the literature in science education about the use of organizers as predictors of students' performance in the redox reaction. The findings suggest that the Ausubel's theory of prior knowledge and this research findings provide new insight into the introduction of advanced organizers in chemistry teaching methods. However, it would be beneficial to see how well the effects hold up outside the study's short-term, small-scale classroom setting. The results are limited in their generalizability due to the demographic studied, and more research is needed to examine the impacts of advanced organizers in other academic settings.

Ethics Approval and Consent to Participate

The researchers used the research ethics provided by the Research Ethics Committee of Federal University Dutsin-Ma and Katsina State Ministry of Education, Nigeria. All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee. Informed consent was obtained from all participants according to the Declaration of Helsinki.

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Conflict of Interests

The authors reported no conflicts of interest for this work and declare that there is no potential conflict of interest with respect to the research, authorship, or publication of this article.

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