International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 6, pp 107-114, June-2023

https://doi.org/10.47001/IRJIET/2023.706017

Chemistry of Mineral Ore Deposit: A Resource for Teaching the Concept of Group Cations and Anions in Experimental Chemistry

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***Abstract* - The purpose of the study was on the chemistry of mineral ore deposits and its application in the teaching of group cations and Anions in experimental chemistry. A total of 120 NCE 1 chemistry students were involved in the study, this number was made up of 73 males and 47 female drawn from two Colleges of Education in Cross River State of Nigeria. 3 research hypotheses and Four (4) research questions were formulated to guide the study. The instruments used in gathering data for the study were Achievement Test in Chemistry (ATC), Chemistry Retention Test and Cognitive Ability Test (CAT). A non-randomized pre-test – post-test control group design was adopted for the study, Kuder-Richardson formula21 was used to establish the reliability of Achievement Test in Chemistry (ATC) and the reliability Coefficient of ATC was 0.83. Data collected were analysed using Analysis of Covariance (ANCOVA) and Scheffe posthoc analysis was used to obtain the direction of significance. From the findings, it was observed that resource materials from the environment were effective in enhancing academic performance scores of chemistry student with high, average and low cognitive ability levels taught using mineral ores and standard materials. Conclusions from the findings led to the recommendation that chemistry lecturers should explore the use of local resource materials within their immediate environment to teach various concepts in science and indeed chemistry.**

Keywords: Mineral ores, Cognitive Ability, Retention, Group cations, Group Anions.

1. Introduction

The relevance of science and technology to National development explains to a large extent the huge commitment and support which most nations make to scientific and technological developments. (Olagunju, 2010: Ireogu & Ige, 2003). This is because one of the indices of global leadership is a nation capacity to employ modern technologies to meet its national needs. Modern development is no longer possible outside the framework of science and technology hence the need to teach science effectively in schools.

Although the history of improvisation in science teaching as reported by osuagwu (1982) was meant to help needy schools in war-torn countries improvise for their needs after World War II (UNESCO, Report, 2000). Improvisation is now imperative due to the absence or shortage of science equipment and materials as well as being a driving force for teachers and students to utilize their cognitive, affective and psychomotor domains in the study of science: Improvisation is a way of widening inquiry, curiosity, creativity and productive application of intellect. It reduces the bad attitudes of some teachers dodging topics due to absence or insufficient science equipment or materials.

One of the pioneer researchers and advocate of the use of local materials in chemistry education is Alonge (2003) who had admitted that we are yet to devise school based experiments to illustrate, justify or explain the usage of locally available material resources or chemicals for chemistry teaching. Reasons for non-utilization could be deduced from the following: Ignorance on the part of the teachers, resourcefulness and fear of accuracy in the course of chemistry experiments involving the use of local materials. (Etuk, 2012). Balogun (2015) advised that in developing learning and teaching materials, the use of learner's environment and locally available resources should be used in providing first hand science experiments. Results from research studies carried out on resource materials suggest that, it yields better retention and transfer of more positive attitudes, (Awolola, 2000). Teaching resources play an important role in boosting the teaching and learning of science as they serve to stimulate thinking and concretize students learning. (Ige, 2008).

Osiyale, (2018) defines teaching resources as all persons and things capable of conveying information, values, processes, experiences and techniques that could geared to

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ISSN (online): 2581-3048
Volume 7, Issue 6, pp 107-114, June-2023
https://doi.org/10.47001/IRJIET/2023.706017

actively engage the students in the learning process. In the school system, there are five types of resources namely.

i. Human resources which include teachers, students and non-academic staff.
ii. Physical resources such as school buildings etc.
iii. Material resources like chalk, blackboard, textbooks, laboratory equipment and teaching aids. iv.Financial resources such as fees, subvention, capital and recurrent expenditure and levies.
iv. Time resources such as school calendar, time for practical classes, assignment and project (Eshiel, 1993).

These resources become integrated for effective communication of science directly or indirectly for the achievement of set objectives in any teaching and learning situation. Thus science teaching can only be meaningful if backed up by necessary resources to enhance skills development.

Emphasis on practical activities in science classroom stems from the fact that science (chemistry) is a practical subject in nature and its progress therefore depends on practical activities and experimentation. It is also true that when learners learn in ways that are natural to them, it brings better academic performance, improves self-esteem, self-confidence and improves basic skills. Thus the use of improvised mineral ore deposits in teaching group cations and Anions in experimental chemistry is in line with current curriculum innovation (Nyenwe, 2002).

Enoahwa and Umeoduagu (2013) observed that 74% of the needed facilities and chemicals for science teaching were either in short supply or non-availability of such materials in the market. It is therefore not uncommon to see schools with large student's population not utilizing any aid in teaching or during practical classes, this results in dwindling interest of students in science and consequently high failure rate, WAEC examiners report (2017 and 2018) have shown failure rate in chemistry to be 32.33% and 56.1% respectively. To this problem, Ezendu (2000) observed that the best way to help the students to learn is to teach the, with the local materials they are familiar with.

Studies have also confirmed the effectiveness of the use of local materials as a resource in science teaching in general and chemistry in particular. Akusoba (2021) pointed out the value of involving students in concrete experience with objects and concepts cannot be over-emphasized as students also interpret data as well as appreciate the nature of science.

Statement of the Problem

Chemistry as a science course is activity oriented and the suggested method for teaching it, which is guided – discovery method is resource – based (FRN, 2013). This suggests that the mastery of chemistry concepts cannot be fully achieved without the use of learning materials in teaching chemistry. So the teaching of chemistry without learning materials will certainly result to poor achievement and lack of interest in the subject.

According to Archibong (2017), any science teaching strategy in which students are involved in activities be it exercise, laboratory work or 'let' find out exercise is conceptualized as activity approach and should be encouraged.

The need for science teachers especially chemistry to be highly creative and resourceful by using learning materials within the local environment is imperative. The deficiency in the teaching of Chemistry concepts could be traced to lack of teaching and learning resources in classroom, (Nwosu, 2000). Also, Chemistry teachers have not been able to utilize learning resources within their environment to enhance teaching and learning of experimental Chemistry, (Umoren, 2002).

Students have difficulties with experimental chemistry and their performances at external examinations have continued to dwindle year by year in Nigeria. This poor performance may be due to inadequate teaching facilities and learning materials. Studies have shown that improvisation through sourcing, selection and deployment of relevant instructional elements of the teaching learning process in the absence or shortage of standard or accredited teaching learning materials can always help in filling the gap especially when the materials are drawn from the learner's local environment (Eshiet, 2002).

Conventional or standard reagents and materials used in teaching experimental chemistry may not have helped in enhancing student's academic performance in experimental chemistry.

The problem of the study is how can student's performance and retention be enhanced, in experiment Chemistry? Will improvised mineral ore deposits also be effective in facilitating students' academic performance and retention in experimental chemistry?. This study seeks to provide an example of the utilization of local materials in the teaching of group cations and Anions in experimental Chemistry.

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ISSN (online): 2581-3048
Volume 7, Issue 6, pp 107-114, June-2023
https://doi.org/10.47001/IRJIET/2023.706017

Purpose of the study

The study was designed to achieve the following specific objectives:

1) To compare the academic performance of students taught using mineral ores with those taught using conventional materials and reagents as resources in teaching the concept of group cations and anions in experimental chemistry.
2) To compare the effects of using mineral ores and conventional materials and reagents as resources in teaching the concept of group cations and anions on student's retention in experimental chemistry.
3) To determine the influence of resource materials on gender and academic performance of chemistry students in the concept of groups cations and anions in experimental chemistry, when taught using mineral ores and conventional materials and reagent.
4) To assess the effects of cognitive ability levels (high, average and low) on students' academic performance in the concept of group cations and anions when taught with mineral ores and conventional materials and reagents.

Research questions

In order to guide the study, the following research questions were raised in the study.

1) What differences exist among the mean performance scores of chemistry students taught the concept of group cations and anions using mineral ores deposit and those taught using standard materials as resources?
2) What differences exist among the mean retention scores of chemistry students taught the concept of group cations and anions using improvised mineral ore deposit and those taught using standard materials?
3) What differences exist between the mean performance scores of male and female chemistry students taught the concept of group cations and anions using improvised mineral ore deposits and those taught using standard material?
4) What is the difference in the mean performance scores of chemistry students with high, average and low ability levels taught the concept of group cations and anions using mineral ores and those taught using conventional materials and reagents as resources?

Research hypotheses

The study specifically tested the following null hypotheses at 0.05 level of significance.

1) There is no significant difference in the mean performance scores of chemistry students taught the concept of group cations and anions using improvised mineral ores deposit and those taught using standard materials.
2) There is no significant difference in the mean retention scores of chemistry students taught the concept of group cations and anions using mineral ores and those taught using standard materials.
3) There is no significant difference in the mean performance scores of chemistry students with high, average and low cognitive ability levels taught the concept of group cations and anions using mineral ores and those taught using standard materials.

2. Research Methods

Research design

The research adopted a non-randomized pre-test and post-test control group design.

Area of Study

The study was conducted in tertiary institutions offering accredited Pre-NCE and NCE programmes in Cross River State of Nigeria. Specifically the tertiary institutions were Colleges of Education Obudu and Cross River State College of Education Akamkpa.

Population

The population of the study covered all year 1 NCE students offering Chemistry/ Biology, Chemistry/ Integrated Science, Chemistry/Mathematics and Chemistry/Physics combinations. The population was 230 student's comprising 120 males and 110 female students in the 2022/2023 session.

Sample and Sampling Technique

A total of 120 students took part in the study using intact classes, out of a population of 230 student's comprising male and female students in the 2022/2023 session in Colleges of Education in Cross River State. This was made up of 73 males and 47 females.

Purposive sampling technique was used to select the colleges from among other colleges. The criteria was

i. College must be co – educational.
ii. College must possess a well-equipped chemistry laboratory.
iii. College must have accredited NCE programmes by the National Commission for Colleges of Education.

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ISSN (online): 2581-3048
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https://doi.org/10.47001/IRJIET/2023.706017

iv. College must have well-staffed and experienced chemistry lecturers.

Four (4) colleges met the above criteria and two (2) colleges among those that met the above criteria were selected by balloting. The two colleges were randomly assigned to experimental and control groups. There were Federal College of Education Obudu and College of Education Akamkpa they were 72 students in the experimental group and 48 students in the control group.

Instruments and Validation

Three researcher's made Achievement Test in Chemistry (ATC), Chemistry Retention Test, (CRT) and Cognitive ability test (CAT) were the instruments used for the study. A total of fifty (50) multiple choice items were constructed on the concepts of group cations and anions, for Chemistry Retention Test (CRT) and Achievement Test in Chemistry (ATC). Also 50 multiple choice items were constructed to determine the cognitive ability levels of students used for the study (CAT) and the results obtained were used to classify students into high, average and low ability levels. The instruments were faced and content validated by two Chemistry experts. Reliability of the instruments were determined using Kuder - Richardson's formula 21. A reliability index of 0.83 was obtained. ATC and CRT were used to determine the academic performance and retention of students in the concepts using mineral ore deposits and standard materials and reagents as teaching resources.

Research Procedure

The following procedure was followed for the administration of the instruments. Permission was obtained from the Heads of departments as well as Chemistry lecturers in each of the colleges that were used for the study. The research assistants were trained for one week and were given detailed instructions on the use of the teacher's instructional guide for conduct of experiments of group cations and anions. The training of the research assistants (Chemistry lecturers) took three phases. Firstly the lectures were briefed on the modalities of the instructional guide and resource materials to be used for the lesson. Secondly the researchers demonstrated the experiments using the resource materials and thirdly the lecturers (research assistants) were asked to teach some students that will not participate in the main lesson using the resource materials.

Pre-achievement test was administered prior to treatment to all the two groups and the results were used as covariates. Also cognitive ability test was administered to students which help to classify students according to ability levels.

The teaching of the concept group cations and anions was done by the research assistants within a period of six weeks in each college using the teachers' instructional guide on experimental detection of group cations and anions developed by the researcher. The instructional guide prepared by the researcher was used to standardize the concept taught by the research assistants. The experimental group was taught the concept using mineral ores as resource materials, while the control group was taught the concept using conventional reagents and materials. The post-test was administered immediately after the treatment to all the groups.

Three weeks after the post-test had been given the retention test was administered. A reshuffled version of Achievement in Chemistry pre-test was administered as post-achievement test (Post-test). Also a reshuffled version of post-test was administered as retention test.

Method of data analysis

The data collected were analysed using descriptive statistics and analysis of covariance (ANCOVA) using pre-test scores as covariates. All hypotheses were tested at 0.05 level of significance.

3. Results and Discussion

The research questions were answered using mean and standard Deviation.

Research Question one (1)

What differences exists among the mean performance scores of Chemistry students taught the concept of group cations and anions using mineral ores deposit and those taught using standard materials as resources?

Table 1: Mean and Standard Deviation Scores of students taught using mineral ores and those taught using conventional materials as resources

Group	N	pre-test		post-test		Mean
		$\bar{X}$	SD	$\bar{X}$	SD	Gain
Experimental	62	24.66	7.98	69.81	5.67	45.15
Control	58	22.95	7.25	54.97	6.32	32.02
Total	120	23.83	7.65	62.63	9.54	38.80

As shown in table 1, the mean gain (45.15) of the experimental group (students taught using mineral ores) is greater than the mean gain (32.02) of the control group (student taught using conventional materials and reagents). This indicates that students taught using mineral ores as a resource performed better than their counterparts taught using conventional materials.

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ISSN (online): 2581-3048
Volume 7, Issue 6, pp 107-114, June-2023
https://doi.org/10.47001/IRJIET/2023.706017

Research Question Two (2)

What differences exists among the mean retention scores of Chemistry students taught the concept of group cations and anions using improvised mineral ore deposit and those taught using standard materials?

Table 2: Mean and standard Deviation scores of Experimental and control group

Group	N	Pre-test		Post-test		Mean
		$\bar{X}$	SD	$\bar{X}$	SD	Gain
Experimental	62	24.66	7.98	59.24	4.94	34.58
Control	58	22.95	7.25	48.14	5.85	25.19
Total	120	23.83	7.65	53.87	7.74	30.04

Table 2 showed that the mean gain (34.58) of the experimental group is greater than the mean gain (25.19) of the control group. This indicates that students taught using mineral ores as a resource material retained better than their counterparts using conventional materials and reagents.

Research question three (3)

What differences exist between the mean performance scores of male and female Chemistry students taught the concept of group cations and anions using improvised mineral ore deposits and those taught using standard materials?

Mean and standard deviation was used in answering this research question.

Table 3: Mean and standard Deviation scores of Experimental and control group based on gender

Group	Gender	N	pre-test		post-test		Mean
			$\bar{X}$	SD	$\bar{X}$	SD	Gain
Experimental	Male	38	25.29	8.19	69.32	5.59	44.03
	Female	24	23.67	7.70	70.58	5.85	46.91
Control	Male	35	22.66	6.73	56.63	5.98	33.97
	Female	23	23.39	8.10	52.43	6.09	29.04
Total	Male	73	24.03	7.59	63.23	8.58	39.92
	Female	47	23.83	7.82	61.70	10.91	37.67

Table 3 showed that the main gain (46.91) of female students in the experimental group was greater than the main gain (44.03) of their male counterparts in the same group while the control group main gain (33.97) of male students was greater than the main gain (29.04) of their female counterparts. On the whole the table showed that the mean gain (39.92) of male students was greater than the main gain (37.17) of their female counterparts.

Testing Research Hypotheses

The following hypotheses were tested at 0.05 level of significance.

Hypothesis One (Ho1)

There is no significant difference in the mean performance scores of Chemistry students taught the concept of group cations and anions using improvised mineral ore deposit and those taught using standard materials.

This hypothesis was tested using the results in table 4.

Table 4: Covariance Analysis (ANCOVA) of student's pre-test performance classified by Resource Materials with pre-test as Covariate

Source	Sum of Squares	Df	Mean Square	F	Sign of F	Decision
Corrected Model	6625.04[a]	2	3312.52	92.00	.000	*
Intercept	40959.91	1	40957.91	1137.50	.000	*
Pre-test	24.78	1	204.78	0.69	.409	NS
Resource Materials	6426.97	1	6426.97	178.49	.000	*
Error	4212.83	117	36.01			
Total	481590.00	120				
Corrected Total	10837.87	119				

*=Significant at .05 level of Significance

NS= Not significant at .05 of Significance As shown in table 4, the calculated probability value (F – value) .000 of the main effect of resource materials is less than the declared probability value (alpha level) .05. Therefore the null hypothesis is rejected. This implies that there exist significant difference in the mean performance scores of chemistry students taught the concept of group cations and anions using mineral ores and those taught using conventional materials and reagents as resources.

Hypothesis two (Ho2)

There is no significant difference in the mean retention scores of chemistry students taught the concept of group cations and anions using mineral ores and those taught using standard materials. This hypothesis was tested using the result in table 5.

Table 5: Covariance Analysis (ANCOVA) of student's Retention Scores classified by Resource Material with Pre-test as Covariates

Source Squares F	Sum of Square	Df	Mean sign of F			Decision
Corrected Model	3706.71[9]	2	1853.35	63.29.000		*
Intercept	30615.35	1	30615.35	1045.41	.000	*
Pre-test	11.85	1	11.85	0.41	.526	NS
Resource Materials	3601.65	1	3601.657	122.98.		
3426.42	117	29.29 * Error				
Total	355435.00	120				
Corrected Total	7133.13	119				

*=Significant at .05 level of Significance NS= Not significant at .05 of Significance. As shown in table 5, the calculated F-value .000 of the main effect of resource material, was less than alpha level. 05. Therefore the null hypothesis is rejected. This implies that there exist a significant difference

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International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 6, pp 107-114, June-2023

https://doi.org/10.47001/IRJIET/2023.706017

in the mean retention scores of chemistry students taught the concept of group cations and Anions using mineral ores and those taught standard materials.

Hypothesis three (Ho3)

There is no significant difference in the mean performance scores of chemistry students with high, average and low cognitive ability levels taught the concept of group cations and Anions using mineral ores and those taught using standard materials.

This hypothesis was tested using the results in table 6.

Table 6: Covariance Analysis (ANCOVA) of students' post-test performance classified by cognitive Ability Levels with Pre-test as Covariates

Source Squares	Sum of Square	Df	Mean	F	Sign of F	Decision
Corrected Model	8129.01[9]	6	1354.84	56.52.000		*
Intercept	39664.00	1	39664.00	1654.58		.000 *
Pre-test	4.31	1	4.31	180.00	.672	NS
Resource Materials	4790.121	1	4790.12	8.39	.000	*
Resource* cognitive ability	611.74	2	305.87	12.76	.000	* Error
	2708.86	113	23.97			
Total	481590.00	120				
Corrected Total	10837.87	119				

*=Significant at .05 level of Significance

NS= Not significant at .05 of Significance.

As shown in table 6, the calculated F-value (.000) of the main effect of cognitive ability level was less than the declared alpha level (.05). Therefore, the null hypothesis was rejected. This implies that there exist a significant difference in the mean performance scores of chemistry students with high average and low cognitive ability levels taught the concept of group cations and Anions using mineral ores and those taught using standard materials.

In order to determine the direction of significance, a Scheffe pair wise comparison test was done and the results summarized in table 7.

Table 7: Summary of Scheffe posthoc comparison of students post test scores classified by reasoning Ability with Pre-test as Covariate

(i) Student's Reasoning Ability	(J) student Reasoning Ability	Mean Diff. (I- J)	Std. Error.	Sign at P< .05
High	Average	.01	1.36	.996
	Low	4.41*	1.51	.004
Average	High	- 01	1.36	.996
	Low	4.41*	1.12	.000
Low	High	-4.41*	1.51	.004
	Average	-4.41*	1.12	.000

*=Significant at P < 0.05 alpha

The mean differences shown in table 7 are 0.01 for high and average reasoning ability; 4.41 for high and low ability, and 4.41 for average and low ability, and 4.41 for average and low ability. The levels of significance display in table 7 indicated that students in high reasoning ability here performed significantly better than their counterparts in low reasoning ability level also performance significantly better than those in low ability level. However, the mean difference between high, and average was not significant.

4. Discussion of Results

The results were discussed under the following headings.

i) Effect of Resource Materials on Students Academic Performance and Retention in Chemistry

The results of investigation as shown in table 4 indicated that a significant difference was found to exist in the mean performance scores of chemistry students taught the concept of group cations and Anions using mineral ores and these taught using standard materials as resources.

This is because the calculated probability value (P – value) .000 of the main effect was less than the declared probability value (178.49).

Results also indicated that a significant difference was found to exist in the mean retention scores of chemistry students taught the concept of group cations and anions using mineral ores and those taught using standard materials. Findings as presented in table 5 show that the calculated Pvalue .000 of the main effect was less than the declared probability value (122.98). The above findings appeared consistent with those of Nworgu (2003), Obi, (2000) and Ezeliora (2001). These studies pointed out that resource material from the environment were effective in enhancing performance and retention in science. Concrete objects provide concrete basis for conceptual thinking and thus facilitates better and proper understanding of chemistry concepts.

ii) Effect of Cognitive Ability levels on student's performance in chemistry

The result of the investigation as shown in table 6 indicated that a significant difference was found to exist in the mean performance scores of chemistry students with high, average and low cognitive ability levels taught using mineral ores and standard materials.

In order to find the order of effectiveness of cognitive ability levels and direction of significance under investigation, scheffe multiple comparison test was employed for posthoc analysis as shown in table 7. The result showed that, high cognitive ability level was the most effective in facilitating students' performance in the concept of group cations and Anions. This was followed by average cognitive ability level

ISSN (online): 2581-3048
Volume 7, Issue 6, pp 107-114, June-2023
https://doi.org/10.47001/IRJIET/2023.706017

while low cognitive ability levels was the least effective in facilitating students' performance in the concept of group cations and Anions.

The result is also in agreement with the findings of Inyang and Ekpeyong (2000). Eze (2002) and Orimogunje (2003) that, students ability level is a significant factor in their performance in chemistry units studied and a significant difference exists between the mean post-test and pre-test scores among students of different ability levels in the learning and understanding of chemistry concepts. The research is also consistent with the findings of Emily, Robert and Micheal (2003) that there was a significant difference between the achievements of high and low ability students. Also, the result is in line with the findings of Adeyemo (2010) that students' ability levels have significant influence on problem solving tasks.

5. Conclusion

Based on the results of the study, it can be concluded that mineral ores also facilitates student's performance and retention in the concept of group cations and Anions in chemistry and also enhances performance and retention. Also high cognitive ability levels is the most effective in facilitating students' performance and retention in the concept of group cations and anions followed by average cognitive ability level and low cognitive ability level.

Recommendation

Based on the results of the study the following recommendations were made.

1) Chemistry teachers should explore the use of local resource materials within their immediate environment to teach various concepts in chemistry.
2) Seminars/ workshops should be organized for chemistry teachers to appraise them with mineral ore concentrates in the learning and teaching of chemistry.

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ISSN (online): 2581-3048
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Citation of this Article:

Umoru James Igui, Ugbe Agioliwhu Ugbe, Ajaba Prisca Ufebe, "Chemistry of Mineral Ore Deposit: A Resource for Teaching the Concept of Group Cations and Anions in Experimental Chemistry" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 6, pp 107-114, June 2023. Article DOI https://doi.org/10.47001/IRJIET/2023.706017

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