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EFFECT OF IMPROVISED INSTRUCTIONAL MATERIALS ON CHEMISTRY STUDENTS' ACADEMIC RETENTION IN SECONDARY SCHOOL

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Abstract

This study investigated the effect of improvised instructional materials on chemistry students' academic retention in secondary school. It covered the topics; acids, bases and acid- base reactions. Two research questions and two hypotheses were used to guide the study, relevant literatures were also reviewed. The study was carried out in Awka education zone in Anambra State. The population of the study consists of 8,583 SS1 chemistry students in the zone. The sample size for the study comprised of 192 SS1 chemistry students. The study adopted quasi-experimental design. Four purposively selected co-educational schools were used for the study of which students of chemistry in two schools were assigned to experimental group which received treatment of involvement in teaching chemistry using improvised instructional materials and the other two schools were assigned to control group which were taught using standard instructional materials. Twenty- five (25) Chemistry retention test (CRT) was used as the instrument. The instrument was validated by expert in science education department and educational foundation. CRT reliability was established using Kudar Richardson 20 (KR-20) which yielded reliability coefficient of 0.81. Mean and standard deviation were used to answer the research questions while analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings of the study revealed that, students taught chemistry with improvised instructional materials significantly achieved more than those taught with standard instructional materials. Also, there was high knowledge retention on the experimental group than the control group. There was no interaction effect of gender and type of instructional materials on students' retention in chemistry. It was recommended that teachers in the teaching field should be trained on the skills of the use of improvised instructional materials. Based on the findings of the study, it was concluded that the use of improvised instructional materials in teaching of chemistry improve the academic retention of students in chemistry.

Keywords: Science, Chemistry, Retention and Improvised Instructional Material (IIM)

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Introduction

Science is important in the development of any nation. This is because science is directly linked to the tackling of the problems of humanity. The contributions of science and technology to the overall development of nations cannot be overemphasized. This is the reason science holds an important position in the curriculum of the nation's educational system. It was in the bid to further underline the importance of science and technology to modern development that Science, Technology, Engineering and Mathematics (STEM) education was introduced in 2001 by the Scientific Administrators at the US National Science Foundation (NSF) with three major goals; to expand the number of students who ultimately pursue advanced degrees/ careers in STEM fields and broaden participation of woman and minorities in those fields, expand STEM- capable workforce and increase STEM literacy for all students including those who do not pursue STEM related careers or additional studies in STEM disciplines (Hallinen, 2011).

STEM education is an integration of interrelated discipline into a new whole, which gives students the opportunity to understand their environment and exploit it for self and national development (Hallinen, 2011). The interdisciplinary nature of STEM makes it unique as it has elements of creativity and objectivity. Strong STEM education is culturally responsive, employs problem-solving and inquiry-based approaches and engages students in hand-on activities that offer opportunities to interact with science professionals (Tera, 2018).

Science, according to Njoku in Dike (2013) is the rational and systematic study of the environment through observation and experimentation with a view to understanding the environment and manipulating the resources of nature for human development. This implies that teaching must be proactive, creative and student centered to achieve the objectives of STEM at secondary school level. Nbina Viko and Birabil (2010) therefore assert that one of the activities of science is experimenting, it provides a forum for putting the theoretical knowledge acquired in the classroom into practice and also, to demonstrate the psychomotor skills of the teacher and students. It helps chemistry students to assimilate abstract and difficult concepts associated with the nature of science. Experimenting in science is however dependent on the availability of instructional materials (Ogwo, 2014).

The lack of instructional materials, non-availability of equipped laboratories among others in the teaching of science in schools is an established issue (Njoku, 2011). This is in line with Odigie (2011) and Dike (2013) who agreed that educational instructional materials and equipped laboratories are lacking in schools. Ibe (2014) is of the opinion that the use of instructional materials to facilitate teaching and learning should be a welcome development. This is in conformity with Dike (2013) who asserts that science teachers should work beyond stereotyped science teaching-learning process and utilize the available materials in the environment to facilitate science teaching-learning process. Therefore for effective teaching of science subjects like chemistry, the use of instructional materials to enrich instruction is very vital.

Chemistry is one of the core subjects of science. As a building block for a range of science disciplines, chemistry has the potential to link other sciences together and to foster greater scientific literacy (Tera, 2018). Chemistry is the basic gateway and the key to modern technology, medicine, engineering and other sciences (Okeke & Nwandinigwe, 2015). The

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study of chemistry is needed to develop the necessary skills, intellectual and mental training needed to observe measure and apply scientific attitude and skill towards natural phenomena that include the eagerness to learn and the ability to think critically. In contemporary Nigeria, great emphasis is placed on science for technological development and chemistry is an important raw material for science. Students are encouraged to take-up science-related subjects such as chemistry. In spite of the relevance of chemistry in the life of the society, the study of chemistry in our secondary schools is challenged with poor performance and lack of interest in the part of students (Uchegbu, Anozieh, MbadiughaIbe & Njoku, 2015).

According to Onasanya and Omosewa (2010) factors responsible for students' poor performances in Chemistry include ; ineffectiveness in teaching process, poor laboratory facilities and inadequate number of learning facilities in schools as against the consistent increase in the number of students. Another reasons adduced for poor achievement in chemistry include abstract nature of chemistry, student and teacher factors, concept difficulty and teaching of chemistry without instructional materials (Nnoli, 2014). Poor funding of schools hinders the school management from providing the chemistry teachers with adequate instructional materials needed for Chemistry teaching. There has been a decline in the performance of students in public examinations conducted by the West African Examination Council (WAEC) and National Examination Council (NECO) in chemistry across the country over the years (Uchegbu, et al., 2015). This is evidently shown in Table.1. The table shows performance of students in WAEC for ten consecutive years.

Table 1: Statistics of Students' Academic Performance in WAEC Chemistry (2007-2018).

Year	Total Sat	Credit Passed (A1-C6)	% Pass	Below Pass (D7-F9)	% Below Pass
2007	424747	196063	46.16	228684	53.84
2008	456980	202762	44.47	254218	55.53
2009	456980	203365	44.49	253615	55.51
2010	465643	263059	50.7	202584	49.3
2011	565692	280250	49.54	285442	50.46
2012	627302	270570	43.13	356732	56.87
2013	639296	462517	72.34	176779	27.66
2014	639268	397649	62.49	241619	37.51
2015	680357	412323	60.6	268034	39.4
2016	706873	408122	57.74	298751	42.26
2017	704494	441576	62.68	262918	37.32
2018	728998	451614	61.95	277384	38.05

Source: Statistics Section, WAEC Office, Yaba Lagos (2018)

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Using the statistics in Table 1 as a case study of performance of students in chemistry examination in secondary schools in Nigeria, it is very clear that general performance of students has not been excellent. It was only in the year 2013 that the percentage performance is above 70% that is 72%. A good percentage of students failed chemistry and this is tantamount to drop in science related professions.

Furthermore WAEC Chief Examiners' report (2018) pointed out that Chemistry students have poor knowledge of acids, bases and acid-base reactions and are unable to report results of acid-base titration experiments, unable to make calculations on molar and mass concentration. These topics are fundamental and basic concepts in chemistry. Judging from the percentage analysis of those who passed chemistry at credit level over the years, there has not been consistent increase in the percentage of students who enrolled and passed at credit level. From 2007-2012, the percentage of those who passed at credit level was below 50% except in 2011. From 2013 to 2018, although, the percentage of those who passed at credit level was above 50%, still a good number of the registered student failed it resulting to dropout in science careers.

Ogwo (2014) stated that the basic tools that science uses in the learning of science processes are instructional materials. Instructional materials are wide varieties of equipment and materials used for teaching and learning processes to stimulate self-activity on the part of the students. According to Engida (2012), instructional materials increase the rate and quantity of learning by students and at the same time allow the teacher to use more time on other gainful activities. They make abstract terms, concepts and generalizations more practical and realistic. Instructional materials create in the learners' awareness of problem, open up possibilities for exploration, present meaningful interactions which naturally lead to provision of solutions. Chemistry as a science subject is hands on activity based and must be taught with instructional materials. Teaching of chemistry without instructional materials result to rote learning. Due to the galloping inflation in the country, foreign exchange rate is high and makes it impossible for schools to purchase already made instructional materials which are often imported into the country. For these reasons and even more, chemistry teachers have been called upon to be creative in improvising these instructional materials. So that in the absence of standard ones or when the number is not adequate, the teacher can locally make use of resources from the environment as an alternative. The importance of using instructional materials whether standard or improvised according to Oriade (2008) is that no matter how good a curriculum may be, the absence of the use of instructional materials can jeopardize its effective implementation. Instructional resources help the teachers to improve their instruction. They make the message clearer, more interesting, standard and easier for the learners to assimilate (Onasanya & Adegbija, 2012). The application and provision of instructional resources should be reinforced in the school system.

There are two major types of instructional materials: conventional (standard) and improvised. The standard materials are conventional instructional materials that are imported or factory made laboratory equipment for teaching science. They are standardized because they adapt to all conditions and serve the same purpose wherever they are used. Examples are laboratory chemicals, laboratory glassware, bunsen burners, tripod stand etc. While Improvised materials refer to a diversity of educational resources that can easily be obtained from the environment, with high local content and relevance to the curriculum (Engida, 2012). They are used as instructional materials for teaching and learning purposes. They are made by the

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teacher or students. Improvised materials include; sodium rich materials as base, such as akanwu, ngu, dyes of plants and flowers (zobo) as acid base indicators.

The teaching of chemistry without instructional materials may certainly result in poor academic achievement. Lack of instructional material in the teaching and learning process of chemistry maybe a contributing factor to poor achievement of the concepts taught. Improvisation according to Ikwuanusi (2011) is the process or act of providing or using alternative instructional resources in the absence of a standard or already made one. Landu (2010) defines improvisation as an act of using materials from local environment designed either by the teacher, students or with the help of local personnel to enhance instruction. Improvisation of instructional resources in secondary school for the teaching and learning of science especially chemistry cannot be overemphasized. National policy on education (2014) stated that the provision and use of available instructional materials for teaching lay a sound basis for scientific and reflective thinking among students. It enables the students to connect abstract concepts taught, to real life experiences known to them. It also encourages students towards the development of creative abilities, strengthens enquiry, discovery, and investigative methods in science. Furthermore, It provides a frame of reference on which students can key their attention during classroom activities, enables teachers to think of cheaper, better and faster methods of making teaching and learning process easier for students, affords students the opportunity of becoming familiar with resources in their environments.

Attah (2014) stated that improvised materials proved superior to standard material in eliciting higher achievement and retention in chemistry students. Therefore it is obvious that improvisation encourages hands on learning and also it is vital for students' high retention in chemistry.

Retention is the ability to store what has been learnt and recall what has been stored in the memory. According to Bichi (2002), retention is the ability to retain and later remember information or knowledge gained after learning into memory. The nature of the resources to be coded contributes to the level of retention (Ibrahim, 2012). Retention is, therefore, the ability to recall learning experiences after about three weeks of learning and beyond. Conditions that relate to poor retention include such factors like lack or inadequate use of instructional. Insufficient use of instructional materials in the process of teaching and learning chemistry can lead to poor retention of knowledge. Attah (2014) noted that retention is high when the degree of original information is high. In other words, any means of teaching that may lead to effective learning may lead to higher retention. Improvised instructional materials contribute to the quality and level of retention in terms of meaningful, concreteness and image evolving characteristics not minding the gender involvement (Ikwuanusi, 2011).

Gender as an important determinant factor in an educational setting constitutes a hindrance to students' retention in chemistry and has received research attention for some years (Attah, 2014). Gender in retention is inconclusive. According to Attah (2014), gender is not a significant factor in students' retention in science. In the other hand, Aninweze (2014) identified sex-role stereotyping and masculine image of science as the origin of the differences between male and female achievement in sciences. In relation to the present study, since gender has proved a significant determinant of academic retention in chemistry

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and in other science subjects, this study wish to investigate the effect of improvised instructional materials on male and female students' academic retention in chemistry.

Realizing the importance of Chemistry in science for national development, a lot of students tend to register chemistry in secondary school. This has resulted to large surge of students in Chemistry giving rise to large number of students in one class. Unfortunately the increase in number of students has not matched with supply of instructional materials in the laboratories. This has made chemistry teachers to teach chemistry with little or no instructional materials. This has constituted difficulties in the teaching and learning of practical chemistry. Without instructional teaching, learning of chemistry which is activity based, does not help the students to understand chemistry concepts.

The consequences are rote learning, lack of interest. Secondly, students have not been performing well in the following chemistry topics acids, base, acid-base reaction, calculations of molar and mass concentration. However, most chemistry laboratories are equipped with standard instructional materials which are at times not enough or even not available. This has made it inevitable for chemistry teachers to improvise. It is against these reasons that the researchers investigated on effect of improvised instructional materials on chemistry students' academic retention in secondary school using theory of discovery learning.

Jerome Bruner postulated the theory of discovery learning (TDL) in 1960. Bruner's theory of discovery learning states that active learning process is one in which the students are directly involved in the structuring and restructuring of their environment and learning experiences. Bruner believes that students selectively perceive certain aspects of their environments, represent those perceptions internally and then act on those internal representations. The theory stresses cognitive effectiveness. Bruner believes that learning by discovery begins when a science teacher intentionally creates a problem and presents it to the students by introducing some contradictions among sources of information which are given in the process of instruction. According to Bruner, such contradictions lead to intellectual discomfort which will motivate the students to initiate individual discoveries through an internal reorganization (cognitive restructuring).

At the enactive stage, the child manipulates the learning materials directly by neuromuscular activities such as experimentation in Chemistry. At the ionic stage, the child deals with mental images of the objects but does not manipulate them directly. At the symbolic stage, the child uses language to manipulate and interpret his/her learning materials. The interpretation of the above is that when a child at secondary school level shows incompetence in his/her learning capability especially in symbolic representation, it could be that he/she was deficient in early stages (that is, enactive and ionic stages) which he/she skipped. It is, therefore, necessary to fill in the missing gap by providing concrete support that will make up for the deficiency. Discovery learning, when encouraged in science instruction may aid problem-solving because learning by discovery starts with problem-solving (Mberekpe 2013).

Enohuean (2015) investigated the effects of instructional materials on the academic achievement and retention of SS 2 biology students in Delta State. 86 sampled SS2 biology students who were randomly selected from a population of 5,626 students drawn from 18 public schools in Delta state were used. Four hypotheses were tested in the study. A quasi-

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experimental design was adopted for the study. The instrument for the study was developed from past WAEC questions by the researcher known as Biology Retention Test (BRT) was validated by some senior lecturers in statistics department from Ahmadu Bello University and senior biology teachers in Delta state. The instrument used which was tested and certified to be reliable at 0.65 coefficients of internal consistency. The data from the study were analysed using mean, standard deviation and analysis of covariance. The following major findings were made: there is a significant difference between the mean academic retention scores of students taught using instructional materials and those taught without the use of instructional materials, there is no significant difference in the mean retention scores of male and female students taught biology concepts using instructional materials. There is a significant difference in the mean retention scores of students taught with instructional materials and those taught without instructional materials. There is a significant difference in the retention ability of male and female students exposed to the use of instructional materials**.** On the basis of these findings, it was recommended that teachers should make use of instructional materials to facilitate the teaching of biology at the secondary school level. This study focused on the subject area of chemistry instead of biology.

Purpose of the Study

The purpose of the study is to investigate the effect of improvised instructional materials on chemistry students' retention in secondary schools. Specifically, the study sought to examine the:

1. Mean retention scores of students taught Chemistry using improvised instructional materials (IIM) and those taught using standard instructional materials (SIM).

2. Mean retention scores of male and female students taught Chemistry using improvised instructional materials (IIM).

Research Questions

The following research questions guided the study;

1. What is the difference in the mean retention scores of students taught Chemistry using improvised instructional materials and those taught using standard instructional materials?
2. To what extent do the mean retention scores differ among male and female students taught Chemistry using improvised instructional materials?

Hypotheses

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

1. There is no significant difference in the mean retention scores between students taught Chemistry using improvised instructional material and those taught using standard instructional material.
2. There is no significant difference in the mean retention scores between male and female students taught Chemistry using improvised instructional materials.

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Methodology

The design of the study was quasi-experimental design of pretest-posttest non-equivalent control group design. Quasi-experimental design is where random assignment of subjects to experimental or control groups is not possible (Nworgu, 2015). In such research, intact classes were used. The design is considered appropriate for the study because treatment and control groups are used.

The study was carried out in Awka Education Zone of Anambra state, Nigeria. Awka Education Zone is in Anambra Central Senatorial District of Anambra state. Greater percentage of occupants in Awka Education Zone are involved in professions like agriculture, and civil servants. In Awka Education zone there are higher institutions both state and federal which are Nnamdi Azikiwe University, Awka, Anambra State Polythechnic, Mgbakwu. Also there is a seat of Government of Anambra State situated in Awka Education zone. Awka Education Zone comprises of five Local Government Areas namely; Awka North, Awka South, Anaocha, Dunukofia and Njikoka local government area respectively. To obtain this study, four co- educational government own secondary schools were chosen out of forty nine (49) co-educational government schools in the area. Two schools were assigned to control group, the other two were also assigned to experimental group. Out of 8583 SS1 students in Awka education zone 192 SS1 students were used. One hundred and four students (104) were assigned to experimental group with fifty four (54) male students and fifty (50) female students. In like manner, eighty eight students (88) were assigned to control group- forty eight (48) male students and forty (40) female students.

Instrument

The instrument for data collection was Chemistry Retention Test (CRT). CRT was developed by the researchers from the West Africa Examination Council (WAEC) past questions. The instrument was validated by two experts, one from department of chemistry Nwafor Orizu Collage of Education Nsugbe and one from department of education foundation Chukwuemeka Odumegwu Ojukwu University Igbariam Campus at reliability of 0.81 using Kuder-Richardson formular 20 (KR-20). Twenty-five (25) multiple choice objective questions covering acids, bases and acid-base reaction. The questions have options lettered A-D for students to choose the correct option; any correct answer earns the student four marks. CRT is divided into two sections; section A- designed to determine the demographic information of the students and section B contained the objective questions**.** CRT was used for achievement tests. Mean and standard deviation were used to answer research questions while analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Results

Research Question 1

What is the difference in the mean retention scores of students taught Chemistry using improvised instructional materials and those taught using standard instructional materials?

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Table 2: Mean and Standard Deviation Scores of the Retention Score for Students Taught Chemistry with Improvised Instructional Materials and those Taught with Standard Instructional Materials.

Instructional Material	N	Mean $\overline{X}$	SD	Mean Difference $\overline{X}$
Experimental Group	104	59.08	7.50	6.51
Control Group	88	52.64	8.16	

Table 2 shows that the mean retention scores of students taught with improvised instructional materials and standard instructional materials were 59.08 and 52.6 respectively. The standard deviation scores for the two groups were 7.50 and 8.16, indicating that students taught with the standard instructional materials had slightly more variability in their retention scores. The difference in mean retention score of 6.5 implies that students taught chemistry with improvised instructional materials had better retention in chemistry than their counterparts taught with standard instruction materials.

Research Question 2

To what extent do the mean retention scores differ among male and female students taught Chemistry using improvised instructional materials?

Table 3: Mean and Standard Deviation Scores of the Retention score for Male and Female Students Taught Chemistry with Improvised Instructional Materials

Instructional Material	Gender	N	Mean $\overline{X}$	SD	Mean Difference $\overline{X}$
Improvised Instructional Materials	Male	54	60.15	7.69	2.23
	Female	50	57.92	7.19	

Table 3 presents the chemistry mean and standard deviation scores in chemistry retention of male and female students taught with improvised instructional materials. The mean retention score of male students was 60.15 whereas female students obtained a mean retention score of 57.92. Their standard deviation scores of 7.69 and 7.19 respectively, show that male and female students taught with improvised instructional materials had comparable variability in distribution of retention scores. . However, the mean gain difference between male and female students was 2.23 in favour of male students. This implies that using improvised instructional materials, male students had better retention in chemistry than their female counterpart.

Hypothesis 1

There is no significant difference in the mean retention scores between students taught Chemistry using improvised instructional material and those taught using standard instructional material.

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Table 4. Summary of Analysis of Covariance of Main Effect of Mean Retention Scores of Students Taught Chemistry Improvised Instructional Materials and those Taught with Standard Instructional Materials.

Source of Variation	Sum of Squares	Df	Mean Square	*F*	*p*-value
Pretest	1678.11	1	1678.11	32.01	.000
Instructional Materials	2103.19	1	2103.19	40.11	.000*
Error	9909.64	189	52.43		
Total	13565.00	191			

*Significant

Table 4 shows there was a significant difference in mean retention scores of students taught chemistry with improvised instructional materials and those taught with standard instructional materials $F(1, 187) = 40.11$, $P = .000$. Since the obtained p-value of .000 was less than the 0.05 level of significance, the null hypothesis which stated that the two groups will not differ significantly was rejected. This implies that students taught chemistry using improvised instructional materials had greater mean retention score than those taught with standard instructional materials. This implies that the significant difference was in favour of those taught chemistry using improvised instructional materials

Hypothesis 2

There is no significant difference in the mean retention scores between male and female students taught Chemistry using improvised instructional

Table 5. Summary of Analysis of Covariance of Mean Retention Scores of Male and Female Students Taught Chemistry with Improvised Instructional Materials.

Source of Variation	Sum of Squares	Df	Mean Square	*F*	*p*-value
Pretest	1408.38	1	1408.38	33.37	.000
Gender	58.42	1	58.42	1.38	.242*
Error	4262.11	101	42.20		
Total	5799.38	103			

*Not Significant

As shown in table 5, there was no significant difference in mean retention scores in chemistry of male and female students taught chemistry using improvised instructional materials, $F(1,101) = 1.38$, $P = .242$. Since the obtained *p*-value of .242 was greater than 0.05 level of significance, the null hypothesis which indicated that there is no significant difference in the mean retention scores of male and female students taught chemistry with improvised instructional materials was not rejected. Though the male students obtained higher mean score than the female students the difference is not enough to be significance difference. This implies that both male and female students received equal effects.

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Discussion

The findings of the study showed that students taught Chemistry with improvised instructional materials showed higher retention than their counterparts taught with standard instructional materials. The result showed a statistically significant difference in retention between the two groups in favour of the experimental group. This result is in conformity with the findings of Ibrahim (2012), who reported that students taught using improvised instructional materials perform excellently well and retain what they had been taught than students taught using standard instructional materials. The result also is in supported of Attah (2014) who revealed that there was significant difference in the mean retention of students taught science subjects with improvised instructional materials than those taught with standard instructional materials.

Chemistry is an experimental science. When chemistry is taught using practical activities through the use of instructional materials, especially with improvised instructional materials, students tend to remember what was taught. Tera (2018) claimed that instructional resources ensure that the learners see/ hear/ feel/ recognize and appreciate as they learn / utilize almost all the five senses at the same time. Bichi (2002) however asserted that improvisation provides a cognitive bridge between students' abstract and standard experience of teaching and learning.

Conclusion

The use of improvised instructional materials enhances students' retention of chemistry. Thus, based on this study, the use of improvised instructional materials is very effective in learning. It helps to improve students' achievement and retention of chemistry by both male and female students.

Recommendations

The following recommendations are made in the light of the findings of the study:

1. Chemistry teachers should use as an alternative to standard instructional materials, improvised instructional materials in the teaching and learning of chemistry.
2. Seminars should be organized by the Science Teachers Association of Nigeria (STAN) on how chemistry teachers could use improvised instructional materials to achieve similar results as standard instructional materials.
3. School administrators should also provide financial support for the acquisition of the materials from which improvised instructional materials can be made since they are cheap and readily available.
4. There is need for the teachers to be resourceful in materials selection and planning.
5. Chemistry teachers should seek individual knowledge on how they can convert local materials in their immediate environment as alternatives to standard materials needed for chemistry instructions.

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