EFFECTS OF GUIDED DISCOVERY AND PROBLEM SOLVING ON ACHIEVEMENT OF SECONDARY SCHOOL STUDENTS' IN VOLUMETRIC ANALYSIS IN NIGER STATE

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ABSTRACT

This study investigated effects of guided discovery and problem solving instructional strategies on achievement of secondary school students in Volumetric Analysis in Minna Metropolis, Niger State. Two research questions and one research hypothesis were tested at alpha level 0.05 of significance. A 3x1 Factorial design was adopted for the study. The population consisted of senior secondary school two (SSSII) students with sample size of 238 students selected from six secondary schools in Minna Metropolis. The research instrument employed was a 24-item Chemistry Achievement Test (CAT) developed from Volumetric Analysis and was validated by six experts in the subject area. The CAT was pilot tested on intact class of Chemistry students and reliability of 0.88 was obtained using Kuder Richardson (K-R$_{21}$). Students were pretested before the treatment began, and the reshuffled or disguised version of the CAT was administered after the treatment in the posttest. The data obtained from both pretest and posttest were analyzed statistically using descriptive statistics (mean, standard deviation) and inferential statistics (Analysis of covariance, ANCOVA) using Statistical Package for Social Sciences (SPSS) version 20.0.The results showed that students in the experimental groups (guided discovery and problem solving) generally have higher mean achievement scores in Chemistry than their counterparts taught Chemistry with conventional teaching method (control group), and this indicates that guided discovery and problem solving strategies have enhanced achievements in Chemistry more than traditional method of teaching. ANCOVA test also revealed that there was a significant difference among the students taught Chemistry using the three instructional strategies, and Scheffe post hoc test indicated that students in the guided discovery group achieved better The hierarchical order of achievement of Chemistry students vis-à-vis the instructional strategies considered in this work is established as: Guided Discovery Problem Solving Conventional Teaching Method. It is concluded that guided discovery and problem solving strategies are more effective in enhancing students' achievements in Chemistry than the convention teaching method. Thus, it is recommended that teachers should expose Chemistry students to guided discovery and problem solving instructional strategies that promote and encourage social interaction, active learning and ultimately enhance achievement. The stakeholders in education sectors should also encourage and enforce the use of guided discovery and problem solving instructional strategies in teaching and learning of Chemistry in particular and sciences in general in our secondary schools.

INTRODUCTION

Chemistry remains a central subject that is invaluable in academic and vocational training. Thus, there is no gainsaying that no meaningful industrial and national developments could be achieved without a thorough understanding of the subject as it aids in the

synthesis of new substances, and in refining and upgrading of the raw materials the nature has endowed us with. It has also been established that Chemistry is a prerequisite to pursuing courses such as Medicine, Pharmacy, Nursing Science, Engineering courses, geosciences (Geology and Geophysics) and other science-related courses which are important ingredients to national development and wealth creation (Olorundare, 2012). It is therefore imperative that secondary school students are well-grounded in Chemistry for Nigeria to attain the state of national development it desires and to rank favourably among the committee of nations. However, it saddens the concerned minds that the performance of students, thereafter refers to students' achievement, in Chemistry in our secondary schools has been consistently poor in external examinations. This ugly situation has been confirmed by the Chief Examiners' Report of West African Examinations Council (WAEC) which attributed poor students' achievement in Chemistry to lack of qualified teachers to handle the subject, poor teaching delivery and teacher's method of presenting the content of the curriculum to students (WAEC Chief Examiners' Report, 2011). Many workers have also identified several factors that are responsible for this ugly situation, and some of these factors on a broad-scale include government-related, society-related, school-related, teacher-related and even student-related factors. More importantly, many researchers have independently attributed the blame to teachers' poor instructional methods (Babatunde, 2004), lack of organization skills and inadequate exposure to instructional strategies (Ayodele, 2002), inadequate experiences of teachers (Olorundare, 2011). There is no doubt from past and present studies that students generally have problems in grasping Chemistry and underachieve in the subject (Adeneye *et al.*, 2011; Babatunde, 2004; Ibe, 2013; Orimogunje *et al.*, 2010; Olorundare, 2011; Sabiru, 2014 and Schmidt, 2000). Nwachukwu (2013) also identified poor

management and control of teacher education programs, teacher training and re-training, selection and organization of curriculum content, curriculum implementation and evaluation, the development, distribution and use of teaching materials, and relevance of curriculum to the needs of society as some factors responsible for poor students' achievements.

It is therefore very crucial to examine the effects of the instructional strategies in use in our secondary schools on the students' achievement bearing in mind the negative consequences of poor performances in deterring students from pursuing Chemistry as a subject, and hence other courses that are critical for national development and technological breakthroughs. The above background explains why most researchers have recently focused their attentions on instructional strategies which they think could foster better understanding and thereby enhance the achievement of students in the subject (Ayodele, 2002).Some of the methods mentioned by the experts are demonstration (Ayodele, 2002), discussion (Busari,2001), guided discovery and self-learning (Akanbi and Akinwole, 2014), collaborative settings (Sabiru, 2014), problem solving (Ajaja,2009), and guided discovery (Agbi, 2006).The effect of the last two methods on the students' achievement in Chemistry is the utmost focus of this work.

Guided discovery is the teaching method that employs exploration, manipulation and experimentation to find out new ideas, and it is a problem solving oriented strategy (Akuma, 2008). In other words, guided discovery instructional strategy is regarded as convergent thinking. The instructor conceives a succession of declarations or questions that guide the learner, step by logical step, making a series of innovations that lead to a single predetermined goal. Succinctly, the teacher initiates a stimulus and the learner reacts by engaging inactive inquiry thereby discovering the appropriate response.

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Problem solving can be well-defined as any kind action a person grosses to channel the cavity between the anticipated solution and the problem itself. Problem solving ability is the ability to bridge the gap between a problem and a solution by using information (knowledge) and reasoning (Akuma, 2008). Research results have shown that students learn meaningfully when they work in small groups as they have the opportunity to negotiate meaning and construct conceptual understanding in community of learners (Agbi, 2006). This is in agreement with a Chinese proverb that says "What I hear, I forget, what I see, I remember, what I do, I understand". The students' ability to achieve within the classroom setting has been largely adduced to the quality of instruction, personality of the teacher and availability of instructional materials among others (Adeshina and Oyebamiji, 2011).

Nwachukwu (2013) viewed achievement basically as the competence a person has in an area of content. This competence is the result of many intellectual and nonintellectual variables. Many researchers have come out with constructive results on the causes of students' poor academic achievement in secondary schools. Of these causes identified by the past workers as earlier mentioned, instructional strategies ranked very high among others as the saying goes in the information and communication technology (ICT) world, "garbage in, garbage out". To this end, if the instructional strategies are depreciated by not encouraging, promoting and improving learners' understanding of the subject, the students' achievements would definitely not be as desired. This paper therefore examines the effects of guided discovery and problem solving instructional strategies on the achievement of secondary Chemistry students in Volumetric Analysis in Minna Metropolis, Niger State, Nigeria.

Science educators, parents and other stakeholders in science education had been worried over the poor performance of students in Senior School Certificate Examinations (SSCE) and West African Senior School Certificate Examinations (WASSCE) Chemistry for quite some time now. In spite of the important position of Chemistry among the science subjects and other related disciplines, available literature on the subject have revealed that students' achievements in Chemistry at Senior Secondary School Certificate Examinations (SSSCE) have been consistently poor (WAEC Chief Examiners' Report 2009 – 2015). A study carried out by Sabiru (2014) also revealed that SSS students have difficulties in learning certain chemical concepts such as solubility, electrolysis, redox reaction, chemical equilibrium and volumetric analysis.

The table 1 below shows the analysis of Chemistry students and their performance in Niger State

Table 1: Analysis of Chemistry Student Performance in Niger State between 2009- 2015

Years	No. of Student Registered	No. of Students Passed	% of Students Passed
2009	8634	636	7.0
2010	9457	574	6.0
2011	7889	622	7.9
2012	9834	452	4.6
2013	7634	345	4.5
2014	8456	562	6.6
2015	7863	453	5.8

Source: Ministry of Education Minna, Niger State

To achieve mastery of volumetric analysis and other concepts in Chemistry, several instructional strategies have been devised and evolved over the years. The earliest and perhaps the least affective teaching method is the expository method, commonly referred to as the traditional method, the lecture method or the chalk and talk method. Science educators have been using the lecture method in teaching volumetric analysis for years but with little or no activities, which makes the concept difficult for students to grasp (Orimoguje *et al.,* 2010). It is realized from the current thinking in instructional methodologies that Chemistry concepts cannot be taught in abstract, students need to conduct themselves in a group and exchange ideas in small group on any given concept for them to understand better. The importance of student-centered methods such as problem solving and guided discovery in science education is well known and advocated in the recent literatures since these strategies lead to functional knowledge or meaningful knowledge. It is for this reason that this research is designed to examine the effect of guided discovery and problem solving learning strategies on students' academic achievement in Volumetric Analysis in Minna Metropolis, Niger State.

This study was aimed at investigating the effects of guided discovery and problem solving instructional strategies, in comparison to conventional method, on achievement of secondary school Chemistry students in Minna Metropolis**,** Niger State, Nigeria. The following two specific objectives were achieved:

(i)   Determination of the effects of guided discovery, problem solving and conventional methods on the achievement of Chemistry students.

(ii)   Comparison of the effects of guided discovery, problem solving and conventional methods on the achievement of Chemistry students.

Research Questions

This work seeks to answer some research questions related to the objectives of the work. The research questions are as follows:

(i)   What instructional strategies have the greatest effect on the achievement of Chemistry students?

(ii)   What is the outcome of secondary school students taught Chemistry using guided discovery, problem solving and conventional strategies?

Hypothesis

The following null hypothesis was formulated and tested at 0.05 alpha levels for their level of significance in order to answer the above research questions.

HO_1: There is no significant difference in the academic achievement of secondary school students taught using guided discovery, problem solving and conventional strategies.

REVIEW OF RELATED LITERATURE

Several workers have carried out researches on the effects of problem-solving, guided discovery and conventional teaching method on the achievement of secondary school students in science subjects Chemistry inclusive, and some of these researchers include Akanbi and kolawole (2014), Jacobson and Obomanu (2011),Julius (2011), Elvan Ezgi and Mustapha (2010). For easier comprehension and more clarity, the work of each of these authors has been discussed separately.

Akanbi and Kolawole (2014) examined the effects of guided discovery (GD) and self-learning (SL) strategies on senior secondary school students' achievement in Biology. The pretest-posttest control group quasi-experimental design with 3x2x2 factorial matrix was adopted. Two hundred and forty (240) SS2

students from six purposively selected senior secondary schools in two local government areas of Oyo State were used for the study. The schools were randomly assigned to experimental (GD and SL) and control (CS) groups and the study lasted for fourteen weeks. Six instruments used were: Teachers Instructional Guides for teachers using the two treatments and control group; Students Environmental Achievement Test (r=0.80), Cognitive Style Test (test-retest r=0.81) and Assessment Sheet for evaluating research assistants. Three null hypotheses were tested at 0.05 levels of significance. Their data were analyzed using ANCOVA and Scheffe post hoc test. Treatment had significant main effect on students' achievement score (F(2,227) = 197.804; p < 0.05). SL enhanced achievement scores (x =14.59) than GD (x = 14.20) and CS (x = 12.53). Self-learning and guided discovery strategies improved students' achievement in Biology.

Jacobson and Obomanu (2011) investigated the effects of problem-solving instructional strategy on student's achievement and retention in Chemistry in River State of Nigeria. A pretest, posttest, non-equivalent control group design was adopted. Two research questions and two hypotheses were respectively tested and answered. Purposive and stratified random sampling was used to select 428 SS II students from two rural and two urban local government areas of Rivers State. These students were randomly grouped into the two treatment groups. The model used is a Generic Problem Solving Inquiry Model developed by Hungerford (1975).

The researcher developed and modified instrument, Chemistry Achievement Test (CAT) and lesson plans were used for the study. The data collected were analyzed using mean, standard deviation (SD) and some gains of achievement and that the hierarchical order of achievement is feedback – corrective (PF), problem solving with model only (PM), and problem solving by the conventional method (PC). No significant differences were observed in the posttest mean scores of urban and rural subjects in the achievement is PF, PM and PC.

No significant differences were observed in the posttest mean scores of urban and rural subjects in the achievement and retention tests administered in the course of the study. Based on the findings, it is recommended that both rural and urban Chemistry teachers use problem solving instructional strategies particularly that in which use of a model is supplemented with feedback-correctives in teaching.

Elvan *et-al*. (2010) worked on investigation of effect of problem solving method on science-process skills and academic achievement. The sample of the research consisted of 86 Third Class teacher candidates who attended science teaching programme of Gazi Education Faculty. Quasi- experimental design which was pretest/posttest control group was implemented in their study. While experimental group (consisting of 41 students) was taught with problem solving method, control group (45 students) was taught with traditional teaching method in their study. Both science process skills test and electric unit achievement test were administered to the two groups before and after the instructions as pretest and posttest respectively. Results of the study revealed that there is no significant difference between experimental and control groups students' pre-science process skills and pre-achievement test scores. Their result also displayed that experimental group students had higher mean scores than control group students in post science process skills and post achievement test.

RESEARCH METHODOLOGY

Research Design

The design adopted for this study is a quasi-experimental experimental design. It is a pretest, posttest, non-equivalent, non-randomized control group

(Fraenkel and Wallen, 2008). A 3 x 1, single treatment factorial design is employed in this study. This design helped to test the effects of three independent variables on the dependent variable (students' achievement in Chemistry).

Sample and Sampling Technique

The sample for this study consisted of 238 students selected from six secondary co-educational schools in Minna Metropolis, Niger State. These schools are Bosso Secondary School, Day Senior Secondary School, Maikunkele B, Day Secondary School Chanchaga A, Day Secondary School Limawa, UBE Tundun Fulani and Zarumai Model School, Minna.   Based on the nature of this research, a three-stage sampling technique was adopted. Firstly, a purposive random sampling technique was adopted to obtain six secondary schools in Minna Metropolis. These schools were purposively sampled based on equivalence (laboratories, facilities and manpower), school type (public, school), and candidates' enrolment (enrolling students for SSSCE Chemistry Examinations for minimum of ten years).

Secondly, the selected six equivalent co-educational schools were assigned to each of the two experimental groups and control group through balloting. Four schools were assigned into experimental group, that is, two into Guided Discovery and two into Problem Solving; and two into conventional method (control group). Thirdly, since only one intact class was used for the study, one arm of Chemistry classes was sampled through balloting.

Research Instrument, its Administration and Method of Data Collection

The research instrument that was used for this study was a 23 – item Chemistry Achievement Test (CAT). The CAT consisted of twenty-three (23) objective items was developed from the concepts that were taught, and it was used to obtain data on students' achievement after the treatments and the same was used for pilot study to determine the reliability of the instrument.

The CAT was designed to measure the six levels of cognitive domains of the students. The number of items measuring each domain level is as shown in Table 2. The necessary procedure for test development, that is, preparation of chart of specification, item construction, content validation, try out for item analysis and revision was followed. The CAT consisted of items with five optional answers A – E (one correct and four distracters) as possible answers to each question raised.

The students were required to indicate the correct answer(s) by ticking or circling the right letter from options A – E. The test is in two sections and the students are expected to respond to both, viz: Section A (Biodata Section) which is designed to obtain information on students' school, class, gender, age, subject and date on which test is administered; and Section B which elicits information on the students' cognitive level based on learned materials (Table 2). The questions and the accompanying answers were validated by the experts in the subject area. A reliability test was also carried out for the instrument using Kuder Richardson (K-R_{21}), which reveals a reliability of 0.88 and this value was considered very adequate for research study.

The students in guided discovery and problem solving groups were instructed by the trained teachers using the appropriate teaching strategies mapped out for each group. Both groups were taught using lesson plans designed using guided discovery and problem solving methodologies. These instructional strategies outline the typical steps a student goes through in the scientific solution of a problem. Students in the control group were not exposed to the guided discovery and problem solving strategies adopted. They were taught by the conventional method of teaching in Chemistry (which

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does not involve a lot of students' activities). The three versions of the lesson plans drawn from the volumetric analysis were prepared and validated. However, the Chemistry teachers of sampled schools were trained as research assistants for a period of one week on the implementation of the methodologies used for the treatment groups under the supervision of the researcher in order to control teacher – effect factor, and the instructions to students in all schools proceeded thereafter.

The CAT instrument was administered to the students at first contact with them during the first week of the study as pretest, and the reshuffled or disguised version of the pretest (instrument) was administered to the students in all the instructional strategy groups in the sampled schools after the sixth week of teaching as posttest. The students' scripts were collated, marked and scored.

Table 2: Specification for Chemistry Achievement Test (CAT).

Content	Knowledge	Comprehension	Application	Analysis	Synthesis	Activity	**Total**
Volumetric Analysis	**4**	**2**	**5**	**4**	**4**	**4**	23

Method of Data Analysis

The data obtained from pretest and posttest were analyzed statistically using descriptive statistics (mean, standard deviation) and inferential statistics(Analysis of covariance (ANCOVA)) using Statistical Package for Social Sciences (SPSS) version 20.0 and the significance of the statistical analyses was ascertained at 0.05 alpha level of significance to test the research hypothesis. The pretest scores were used as covariates, thus serving to adjust for the initial differences between and within groups.

RESULTS

The results of this study are presented based on research questions and hypotheses

Hypothesis

There is no significant difference in the academic achievement of secondary school student taught Chemistry using guided discovery, problem solving and conventional strategies.

Research Question One

Which of the instructional strategies has the greatest effect on the achievement of Chemistry students?

Research Question Two

What is the outcome of secondary school students taught Chemistry using guided discovery, problem solving and conventional strategies?

In a bid to determine the instructional strategy that has the greatest effect on achievement of Chemistry students among the three instructional strategies considered in this work, namely: experimental group 1 (guided discovery), experimental group 2 (problem solving) and the control group (conventional method); descriptive statistics (mean and standard deviation) test was carried out, and the results are as shown in Table 2. In the same vain, in order to show the instructional strategy that has the greatest effect on the learning after treatment, the mean gain scores between the pretest and posttest mean scores of the three groups (guided discovery, problem solving and

conventional methods) were computed and reported in Table 2. Figure 1 gives a quick look in comparing the mean scores students taught Chemistry using guided discovery, problem solving and conventional method in pretest and posttest.

From Table 2, it is observed that students in the three groups had benefited from all strategies. It is worth mentioning that guided discovery had the highest mean gain score of 49.97 with standard deviation of 3.65 followed by problem solving strategy with the mean gain score of 37.57 and standard deviation of 3.59; while the conventional method had the least mean gain score of 31.59 with standard deviation of 3.57. This indicates that all the groups benefited from the treatment, with guided discovery having the best posttest Chemistry achievement.

Table 3: Mean gain scores and standard deviation of students taught chemistry using guided   discovery, problem solving and conventional method

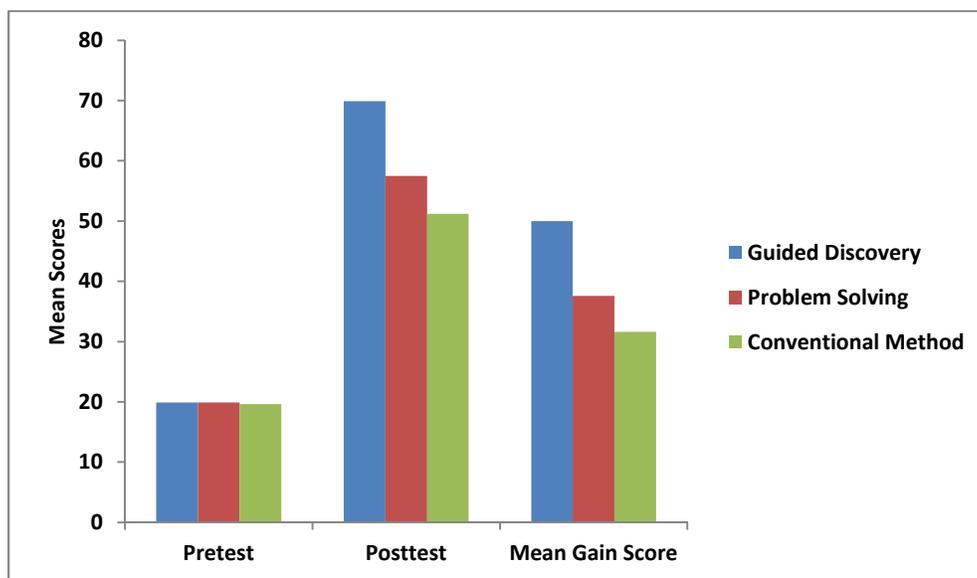| Groups	Pretest		Posttest		Gain Score	
	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Guided Discovery	19.91	3.65	69.88	8.59	49.97	3.65
Problem Solving	19.90	3.54	57.47	7.01	37.57	3.59
Conventional Method	19.63	3.42	51.22	7.11	31.59	3.57

Fig. 1:   Comparison of the mean scores students taught Chemistry using guided discovery, problem solving and conventional method in pretest and posttest.

In order to determine whether there was a significant difference in the posttest mean scores of the experimental group 1 (guided discovery), experimental group 2 (problem solving) and the control group (conventional method), analysis of covariance (ANCOVA)

test was carried out using the pretest as a covariate, and the results are as shown in the Table 3.

Table 4: Analysis of covariance of posttest scores of the treatment groups (guided discovery, problem solving and control group conventional method using the pretest as covariate.

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	12992.759	3	4330.920	76.607	0.000
Intercept	87727.394	1	87727.394	1551.765	0.000
Pretest	4.759	1	4.759	0.084	0.000
Treatment	12873.296	2	6436.648	113.855	0.000
Error	13172.406	233	56.534		
Total	837765.000	237			
Corrected Total	26165.165	236			

* Significant at 0.05 alpha level

An examination of Table 4 reveals that that an $F_{(2, 236)} = 113.855$, p = 0.000, which is less than 0.05 (i.e. p-value < -value), suggesting that the main effect (treatment) was significant. The results indicate that the method of instruction produced a significant effect on the posttest achievement scores of Chemistry students when covariate effect (pretest) was controlled. Thus, the treatment using guided discovery, problem solving and conventional method accounted for the difference in the posttest achievement score of the students, and the difference is significant.

Since it was established that there was a significant difference in the posttest scores of the groups, Scheffe post-hoc analysis was carried out to locate the direction of the difference among the treatment groups. The results of this post-hoc analysis are shown in Table 5.

Table 5: Scheffe analysis of significant difference of students' achievement using guided discovery, problem solving and conventional method.

Groups	Guided Discovery	Problem Solving	Conventional Method
Guided Discovery	-	12.42*	18.66*
Problem Solving	-12.42*	-	6.24*
Conventional Method	-18.66*	-6.24*	-

*Significant at alpha level of 0.05

From Table 5 it could be observed that group 1 (guided discovery) compare to group 1 is not significant (-), group 1 compare to group 2 (problem solving) is significant with the positive value of 12.42 in favour of group1, and finally group 1 compare to group3 (conventional method) is also significant with positive value of 18.66 in favour of group1. It can also be deduced from Table 5 that group 2 (problem solving) compare to group 1 (guided discovery) is significant with negative of -12.42 in favour of group 1, group 2 compares to group 2

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is not significant (-), but group 2 when compares to group 3 is significant with a positive value of 6.24 in favour of group 2. Group 3 is significant compare to group1 but with negative value of -18.66 in favour of group1. Moreover, group 3 compares to group 1 is significant but with negative value of 6.24 in favour of group two (problem solving).

Summary of Findings

The major findings obtained from the research question and research hypothesis of this study are summarized as follows:

(i)   There was a significant difference in the achievement of Chemistry students taught using guided discovery, problem solving and conventional method in favour of the students in experimental groups (guided discovery and problem solving).

(ii)   The best strategy among the strategies considered in this study is guided discovery.

DISCUSSION

The results of this study reveal that there is a significant difference among the students taught Chemistry using guided discovery, problem solving and conventional teaching strategies. This finding is agreement with findings of Akanbi and Kolawole, (2014) and Elvan *et al.* (2010) but disagree with findings of Jacobson and Obamanu (2011). Independent interpretations from both descriptive statistics and analysis of covariance (ANCOVA) showed clearly that the best strategy among the strategies considered in this study is guided discovery. The hierarchical order of achievement and importance of the instructional strategies considered is thus:

Guided Discovery   Problem Solving   Conventional Teaching Method

Thus, both guided discovery and problem solving strategies are much better in enhancing students' achievements in Chemistry than the conventional teaching method. This is may be due to the fact that all sense organs and other parts of the body of the students were involved in learning and they were left to discover the knowledge on their own when subjected to both guided discovery and problem solving strategies. The students in the class were able to take control of their study with the guidance of the subject teacher. This finding concur with findings of Akanbi and Kolawole, (2014) and Agbi, (2006) who found that there is significant difference between the student taught Chemistry using guided discovery and those taught chemistry using conventional method but disagree withfindings of Jacobson and Obamanu (2011) who reported that no significant differences were observed in the posttest mean scores of urban and rural subjects in the achievement is PF, PM and PC.

CONCLUSIONS

The following conclusions are made from the findings of this study:

(1)   This study indicates that instructional strategies that teachers employ in teaching Chemistry have significant effects on students' achievement.

(2)   Students' achievement in chemistry seriously differ with students taught using guided discovery having the highest scores followed by those taught using problem solving and the least achievers are those taught with   conventional method.

(3)   The guided discovery ranked the best strategy among the strategies considered in this study.

The findings of this study have strong implications for teaching and learning of Chemistry in secondary schools in Nigeria, and some of such implications recognized include:

(1) The achievement of students in Chemistry would be greatly improved if students are exposed to varieties of practical – oriented learning strategies such as guided discovery and problem solving.

(2) The use of guided discovery and problem solving as instructional strategies in Chemistry classrooms would serve as a motivator, which could encourage students to come to class and actively participate during Chemistry lessons.

(3) Guided discovery and problem solving instructional strategies when integrated into Nigerian classrooms would assist to produce better achievement of students in Chemistry in particular and other science-related subjects in general.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proffered:

(1) Teachers should expose Chemistry students to guided discovery and problem solving instructional strategies that promote and encourage social interaction, active learning, discovery learning, motivation, learning by doing and learning by experience which enhances achievement.

(2) Secondary school teachers should be trained and retrained on how to use guided discovery and problem solving effectively in the classroom.

(3) The stakeholders in education sectors such as curriculum planners, State and Federal Ministries of Education and so onshould advocate making guided discovery and problem solving instructional strategies the essential instructional strategies for teaching and learning in the secondary school curriculum.

(4) The teacher education should be geared towards preparation of Chemistry teacher to acquire and maintain appropriate guided discovery and problem solving strategies which strongly enhance achievement of Chemistry students at secondary school level

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