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ORIGINAL ARTICLE

COMPARISON OF THE EFFECTS OF GUIDED DISCOVERY, PROBLEM SOLVING AND CONVENTIONAL TEACHING METHODS ON RETENTION OF SECONDARY SCHOOL CHEMISTRY STUDENTS IN MINNA METROPOLIS, NIGER STATE

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ABSTRACT

Background: Chemistry holds a very important position in the secondary school curriculum as it is one of the science subjects upon which several science and technology courses such as medicine, agriculture and engineering just to mention a few at higher level of education are based. It is no gainsaying that without proper understanding of Chemistry, the goals and aspirations of our national development might not be fully achieved. Despite the role of this invaluable subject, the secondary school students in Nigeria and elsewhere are consistently having poor achievement in Chemistry and this ugly situation is very worrisome. Thus, the researchers resort to seeking instructional strategies that are student-centered, and that enhance students' achievement and ultimately retention. **Objectives**: Thus, this study investigates the effects of guided discovery and problem solving instructional strategies, in comparison to conventional teaching method, on retention of secondary school Chemistry students in Minna Metropolis, Niger State, Nigeria. **Material and Methods**: A 3x 1 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 Retention Test (CRT). The CRT was pilot-tested on intact class of Chemistry students and reliability of 0.88 was obtained using Kuder Richardson ($K\text{-}R_{21}$). Students were pretested before the treatment began, and the reshuffled or disguised version of the Chemistry Achievement Test (CAT) was administered after the treatment in the post-posttest. The data obtained from both pretest and post-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. **Results**: The results showed that students in the experimental groups (guided discovery and problem solving) generally have higher mean retention 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 retention 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 best. The hierarchical order of achievement of Chemistry student's vis-à-vis the instructional strategies considered in this work is established as: Guided Discovery > Problem Solving > Conventional Teaching Method. **Conclusions:** This study indicated that instructional strategies that teachers employ in teaching Chemistry have significant effects on students' retention, and that the guided discovery is ranked the best among the strategies considered in this study. It is concluded that guided discovery and problem solving strategies are more effective in enhancing students' retention in Chemistry than the convention teaching method. Thus, it is recommended that secondary school teachers should expose Chemistry students to guided discovery and problem solving instructional strategies that promote and encourage social interaction, active learning and ultimately enhance retention. 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.

Keywords: *Guided Discovery, Problem Solving, Retention, Chemistry, Minna Metropolis, Nigeria.*

1. INTRODUCTION

The natural world is made of chemical compounds and all life forms on earth depend on the efficient interactions between these chemical components for their existence. A host of technologies critical for human success, ranging from the treatment of pathogenic disease through food production to controlling pests, require an understanding of chemical interactions between organisms. Understanding the nature of the chemical and physical properties of substances and natural matrices is critical to our ability to isolate, characterize, produce and use the chemistry of nature to improve our livelihoods in a sustainable manner. Without proper understanding of Chemistry, the goals of our national development might not be achieved [1].

Chemistry is one of most invaluable science subjects at secondary school level in Nigeria and elsewhere. However, students are running away from this important subject due to some avoidable reasons such as method of instruction that is teacher-centered, unavailability of competent and trained teachers, lack of standard laboratory, lack of in-service training for old teachers, students' study habit, students' attitude and anxiety for Chemistry which prevent them from retaining the class lessons [2]. This informed the researchers to consider it very important to look for teaching methodologies that are student-centered such as guided discovery and problem solving strategies among others which they believe can improve retention of Chemistry concepts.

Retention can be described as the ability to remember things learned by individual at a later time [3]. This expert opined that ability to remember things learned by the individuals at later time is necessary for better achievement. Retention takes place when learning is coded into memory and appropriate coding of incoming information provides the index that may be consulted thereby enabling retention to take place without an elaborate memory search. Retention is very paramount to achievement most especially in Chemistry in particular and sciences in general. Researchers have been working on strategy that will increase retention of individual students at all levels of education in Nigeria to enhance the achievement of student at standard examinations [4, 5, 6, 7, 8]. For example, Bawa (2010) worked on effects of problem solving instructional strategy on academic achievement and retention in ecology among secondary school students with different cognitive preferences in Zaria educational zone, and it was found that problem solving has a significant effect on students' achievement and retention [6] which is in contrary to the view of Obamanu and Jabcobson (2011) in River State [9].

Problem solving can be viewed as the sum total of the actions a student takes to bridge the gap between the anticipated solution and the problem itself. Problem solving ability is therefore an ability to bridge the gap between a problem and a solution by using information (knowledge) and reasoning. Chemical problem-solving as a process involves bridging the gap between a problem and a situation using chemical knowledge [10]. This shows that problem-solving in Chemistry requires the prerequisite knowledge to reason through the problem in order to arrive at the solution [11].
Guided discovery is one of those teaching methods that employ exploration, manipulation and experimentation to find out new ideas and it is a problem solving oriented strategy [12]. This instructional strategy is characterized by convergent thinking. The instructor devises a series of statements or questions that guide the learner, step by logical step, making a series of discoveries that lead to a single predetermined goal. In other words, the teacher initiates a stimulus and the learner reacts by engaging in an active inquiry thereby discovering the appropriate response. The guided discovery method is a student-centered, activity-oriented teaching method in which the teacher guides the students through problem-solving approach to discover answers to the questions. This method lends itself meaningfully to integration of theory and practical works, and each activity is followed by a discussion. Most studies in recent years have investigated topics in secondary school curriculum which pose learning quantitative problem-solving [1-8, 13, 14, 15]. For example, Ibe (2013) worked on guided inquiry in Imo State and the work revealed that there is a significant difference between student taught Chemistry using guided inquiry and those taught using expository method [1].

This work examined effects of guided discovery and problem solving on retention of secondary school students in Minna Metropolis, Niger State, Nigeria.

1.1 Statement of the Problem

For more than a decade now, the different instructional strategies employed in teaching Chemistry have not improved students' retention in the subject to any appreciable extent. This mean that the most desire scientific and technological application of Chemistry cannot be sustained. The implication is that the teaching of Chemistry does not lead to students' understanding of concepts, functionality and application of its ideas. Hence, there is need to find pedagogic approaches that promote active learning. Therefore, this study examined effects of guided discovery and problem solving strategies on retention of secondary school Chemistry students in Minna Metropolis, Niger State.

1.2 Purpose of the Study

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

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

1.3 Research Questions

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

(i) Which of the instructional strategies has the greatest effect on the retention of Chemistry students?
(ii) What is the retention ability of secondary school students taught Chemistry using guided discovery, problem solving and conventional strategies?

1.4 Null Hypothesis

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

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

2. RESEARCH METHODOLOGY

2.1 Research Design

The design adopted for this study is an experimental design. It is a pretest, posttest, non-equivalent, non-randomized control group [16]. A 3 x 1, single treatment factorial design was employed in this study. This design helped to test the effects of three independent variables on the dependent variable (students' retention in Chemistry).

2.2 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.

2.3 Research Instrument

The research instrument that was used for this study was a 40 – item Chemistry Retention Test (CRT). The CRT consisted of twenty-three (23) objective items which was developed from the concepts that were taught, and it was used to obtain data on students' retention two weeks after the treatments and the same was used for pilot study to determine the reliability of the instrument.

The CRT 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 1. The necessary procedure for test development, that is, preparation of chart of specification, item construction, content validation, and try out for item analysis and revision was followed. The CRT 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 1). 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 ($K\text{-}R_{21}$), 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 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 CRT 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 1: Specification for Chemistry Retention Test (CRT).

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

2.4 Method of Data Analysis

The data obtained from pretest and post-posttest (retention test) 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.

3. RESULTS

The results of this study are presented in this section.

3.1 Research Question One

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

3.2 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 retention 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 47.91 with standard deviation 3.94 followed by problem solving strategy with the mean gain score of 36.22 and standard deviation of 2.45; while the conventional method had the least mean gain score of 24.58 with standard deviation of 1.68. This indicates that all the groups benefited from the treatment, with guided discovery having the best posttest Chemistry retention.

Table 2: Mean retention scores of students taught chemistry using guided discovery, problem solving and conventional method.

Groups	**Pretest scores**	**Pretest Std**	**Post-posttest mean score**	**Post-posttest std**	**Post-post Mean Gain**	**Difference in Std**
Guided Discovery	19.91	3.65	67.82	7.59	47.91	3.94
Problem Solving	19.90	3.54	56.12	6.01	36.22	2.45
Conventional Method	19.63	3.43	44.21	5.11	24.58	1.68

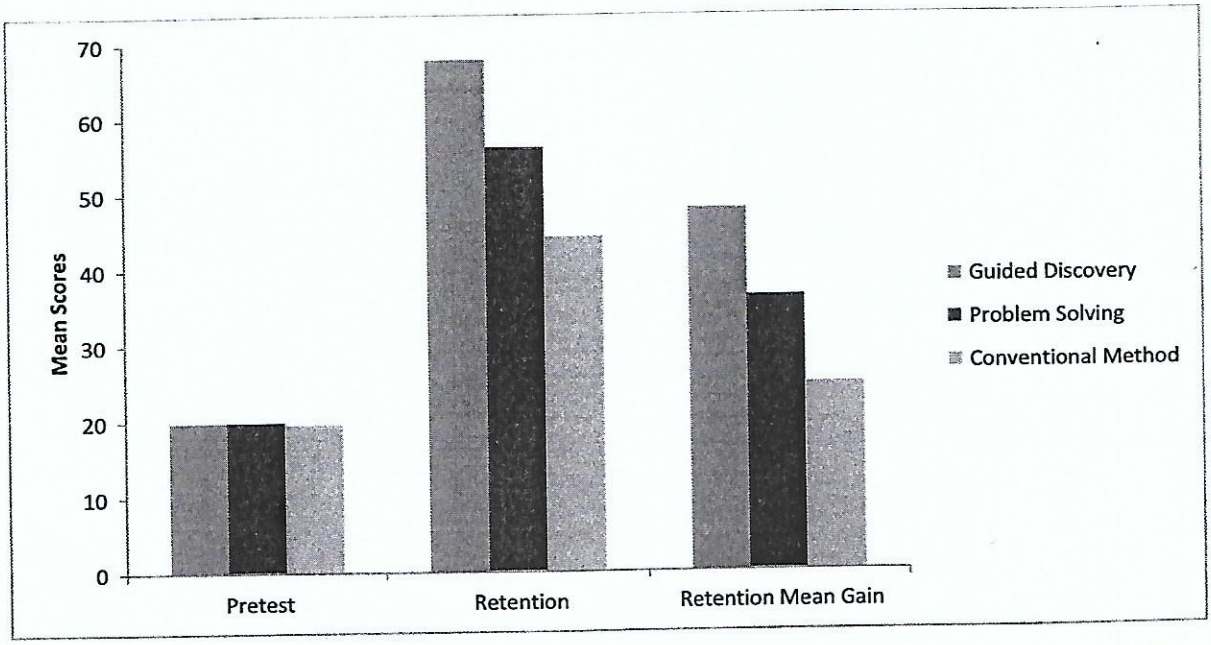

Figure 1: Comparison of the mean scores students taught Chemistry using guided discovery, problem solving and conventional method in pretest and posttest.

3.3 Research Hypothesis

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

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 3: Analysis of covariance of mean retention scores of student's taught Chemistry using guided discovery, problem solving and conventional method

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	10072.113	3	3357.371	59.023	0.000
Intercept	81603.122	1	81603.122	1434.595	0.000
Pretest	88.801	1	88.801	1.561	0.000
Treatments	9830.089	2	4915.045	86.407	0.000
Error	13253.584	233	56.882		
Total	814342.000	237			
Corrected Total	23325.696	236			

*Significant at 0.05 alpha level.

The result of the analysis in Table 3 indicates that an F (2, 236) = 86.41, p = 0.00 for the main effect was significant at 0.05 alpha level. This implies that there is a significant difference in the retention score of students taught Chemistry using guided discovery, problem solving and conventional methods. As a result of the establishment of a significant difference, a post-hoc analysis using Scheffe test was conducted to determine the direction of difference among the three retention scores. The results of the analysis are as shown in Table 4.

Table 4: Scheffe Analysis of significant difference on mean score of students' retention Score taught Chemistry 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 4, the Scheffe's post hoc analysis shows that group 1 (guided discovery) is not significant with group 1, while group 1 is more significant when compared to group 2 (problem solving) with a positive value of 12.42 in favour of guided discovery. In addition, group 1 much more significant when compared to group 3 (conventional method) with positive value of 18.66 in favour of guided discovery. It can also be deduced from Table 4 that group 2 is more significant when compared to group 3 with a positive value of 6.24 in favour of group 2 (problem solving). The more significant group (method) in the pairs as explained above indicates that it is a more effective teaching strategy.

3.4 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 retention 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).

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

4. 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. Independent interpretations from both descriptive statistics and analysis of covariance (ANCOVA) also showed clearly that the best strategy among the strategies considered in this study is guided discovery. The hierarchical order of retention 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' retention 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 concurs with findings of Akanbi and Kolawole (2014) and Ibe (2013) [13-1] who found that there is significant difference between the student taught Chemistry using guided discovery and those taught chemistry using conventional method but disagree with findings of Jacobson and Obomanu (2011) [9] 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.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 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' retention.
(2) Students' retention 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 retention 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 retention of students in Chemistry in particular and other science-related subjects in general.

5.2 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 retention.
(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 should 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 teachers to acquire and maintain appropriate guided discovery and problem solving strategies which strongly enhance retention of Chemistry students at secondary school level.

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