The Relative Effectiveness of Guided Discovery and Demonstration Teaching Methods on Achievement of Chemistry Students of Different levels of Scientific Literacy

Nbina, J. B.
Department of Curriculum Studies and Educational Technology
University of Port Harcourt, Port Harcourt, Rivers State, Nigeria
E-mail: drnbinajacobson@yahoo.com

ABSTRACT

The study was conducted to assess the relative effectiveness of guided discovery and demonstration teaching methods on achievement of chemistry students of different levels of scientific literacy. Two research questions and two null hypotheses were formulated and tested respectively. Two instruments, namely: Chemistry Achievement Test (CAT) and Scientific Literacy Test (SLT) were used for data collection. A quasi-experimental design was adopted. Results indicate that the guided discovery method was significantly superior to the demonstration teaching method in enhancing cognitive achievement in chemistry for all levels of scientific literacy students. For the guided discovery and demonstration teaching methods, the higher the scientific literacy levels, the higher the achievement of students in chemistry. It was recommended that: the government should encourage science teachers to use guided discovery method by providing needed conducive environment for teaching and learning with adequate instructional materials; in service training of science teachers on how to use guided discovery is needed since most of such innovative teaching method; and science teachers should no longer be contented with teaching for acquisition of knowledge alone but should also teach for inculcation of scientific literacy.
Keywords: *Demonstration, teaching, guided discovery, chemistry achievement, and scientific literacy*

INTRODUCTION

Achievement in the teaching and learning process has to do with attainment of set objectives of instruction (Nbina and Obomanu, 2011). Studies have shown that the teaching of science in Nigerian secondary schools falls short of the standard expected of it. Most of the methods used in teaching have been described as inappropriate and uninspiring (Ibe, 2004; Madu, 2004; Shaleigh, 2004). These methods include drill, lecture, diagnosis, direct observation, field trip, group work, manipulation, modeling, reading and recitation. Nnaobi (2007) assert that there is no best method of teaching but that effective scientific teaching should be laboratory-centered and activity-oriented rather than textbook or lecture-dominated methods which seem to characterize the Nigerian schools. In science instructions for instance, if a learner accomplishes a task successfully and attains the specified goals for a particular learning experience, he is said to have achieved. The attainment of the goals of science education is a major concern of education policy makers and one of such goals is the inculcation of scientific literacy (FRN, 2004). Scientific literacy has been viewed from various perspectives by different science educators. For instance, Olufolajimi (1985) in Eze (2003) views scientific literacy as it relates to the functional attributes of a science

teacher while Arons (1983) characterizes a scientifically literate person as one who knows something about the nature and limits of science and the scientific method. Arons was of the view that for one to be adjudged literate in science, he or she should not only have enough knowledge for continual informal learning about science and for intelligent reading of scientific articles but should also possess the inclination to do so. Generally, Scientific Literacy (SL) can be seen as a human attribute, which is essentially characterized by an ability of the individual to acquire scientific knowledge and apply same to the solution of societal problems. Scientific literacy can be acquired, not only through school learning but also through interaction with objects and people in one's immediate environment, engaging in scientific discussions and scientific-related activities. The foundation of scientific literacy is laid in schools especially secondary school, through the use of innovative teaching methods such as the guided discovery methods (Eze, 2003). According to Akinsete (2006), it is a method of teaching that encourages a child to solve problems by seeking and asking questions so as to gather information. Guided discovery involves discovery in which there is creativity and students participation in a well equipment laboratory (Adamu 2001). He also notes that this method of teaching aids conceptualization, memory and helps to develop students understanding of science. Adeoye and Alayande (2009) in the same vein, summarized that this method makes activities enjoyable, accessible and promote students language and communication skills. The guided-discovery method is a student-centered, activity- oriented teaching strategy in which the teacher guides the students through problem-solving approach to discover answers to instructional topics at hand (Abdullahi, 2007). It is also thought that students of higher scientific literacy level achieve better in science. Demonstration method is a teaching strategy which involves experimentation. Demonstration can be carried out by the teacher for the students to observe and/or the teacher and other students to observe (Nwachukwu and Nwosu, 2007, Nbina and Arokuyu, 2009).

However, the success of some known innovative and effective methods may be predicated on the level of exposure students have had in basic day-to-day science concepts and methods of discovery. This implies that students' level achievement even when new methods of teaching are used. Based on this, students can be categorized as having high, medium and low scientific literacy using some acceptable criteria. To this end, the guided discovery and the demonstration teaching methods are related to learner's characteristics scientific literacy level to see what the effect on achievement in chemistry will be like. A number of teaching strategies such as lecture/expository, discussion, inquiry, demonstration, concept mapping, co-operative learning etc have been employed in teaching chemistry over the years but performance in senior secondary school certificate examination in chemistry continues to be poor. These raise some doubts as to whether there are other variables like the scientific literacy level that inhibit the cognitive processes of students in chemistry. Hence, this study sets out to:

1. Assess the effectiveness of guided discovery and demonstration teaching methods on achievement of chemistry students of different levels of scientific literacy.
2. Identify the interactive effects of teaching methods and scientific literacy levels on achievement in chemistry.

The following research questions guided the study:

1. Is there any significant difference in the mean achievement scores of students of high, medium and low levels of scientific literacy taught chemistry using guided-discovery and demonstration teaching methods.
2. Is there any significant interaction between the two teaching methods and scientific literacy levels on students' achievement in chemistry.

Two null hypotheses were tested at 0.5 levels of significance.

$H_0$1: There is no significant difference in the mean achievement scores of students of high, medium and low levels of scientific literacy taught chemistry using guided-discovery and demonstration teaching methods.

$H_0$2: There is no significant interaction between the two teaching methods and scientific literacy levels on students' achievement in chemistry.

METHOD

The sample consisted of one hundred and forty five senior secondary two (SS2) chemistry students from six intact classes randomly selected from six secondary Schools in Port Harcourt Education Zone of Rivers State. The study was a quasi - experimental design. The design was used because intact classes were involved. A pre-test, post -test non-equivalent control group was also used for the study. Sample random sampling techniques were employed to select the participating schools as well as assigning the schools experimental and control groups. For the experimental schools, there were three intact classes consisting of one class of boys, one class of girls and one class of co-educational students. The same also applies to the control schools. Students in the experimental schools were taught a chemistry concept (water) using the guided discovery method while those in the control schools were taught the same concept using the demonstration teaching method. Two instruments were used for data collection, these are: Chemistry Achievement Test (CAT) and Scientific Literacy Test (SLT). The chemistry achievement test (CAT) is a 50 item multiple choice test developed by the researcher based on the chemistry concept taught. A test- blue print was developed based on the relative emphasis on each of the sub topics in the curriculum (see Table 1).

Table 1: Test Blue Print for CAT Construction

Topic (content)	No. of periods	Knowledge (30%)	Application (34%)	Higher-order level (36%)	Total
Sources, composition, water as solvent chemical test & treatment of water.	1	2	1	3	6
Hardness & types of hardness of water	1	2	2	1	5
Causes, advantages & disadvantages of hardness, softening of hard water.	2	2	2	4	8
Saturated, unsaturated & supersaturated solution.	2	2	5	1	8
True & false solutions, suspension	2	2	2	2	6
Solubility	1	1	1	1	3
Determination of solubility at different temperatures.	1	2	2	3	7
Solubility graphs, curves & their use for calculations,	2	2	2	3	7
Total	12	15	17	18	50

CAT was subjected to validity by giving the items to three experts (one in measurement and evaluation in University of Port Harcourt, Faculty of Education and two experienced chemistry teachers in secondary schools). The validation was also done by making sure that the test items reflected the specifications on the test blueprint. The Scientific Literacy Test (SLT) was used to categorize students into levels of scientific literacy. It consists of four sections, each representing an aspect of scientific literacy being considered in this study. Sections one and two comprised of multiple-choice items based on knowledge and application of science respectively. Section three was composed of short essay questions and negative scientific statement on appreciation of science. Each of the sections was weighted as follows:

Section one with 16 multiple-choice items made up 32%
Section two with 14 multiple-choice items made up 28%
Section three with 2 short essay type items made up 4%
Section four with 18 scientific statements made up 36%

The total score for each student on the scientific literacy test was scored as a percentage and this was used as the basis for categorizing students into levels of scientific literacy as follows:

70% and above - High level of scientific literacy
50% -60%- Medium level of scientific literacy
0% -49% -Low level of scientific literacy

The reliability of each section of the test was established. Thus, for sections one and two involving multiple-choice questions, Kuder Richardson formula 20 were used. For sections three and four, which have responses, weighted differently, Cronbach alpha formula was weighted based on the difficulty level of the items. The calculated r-values were 0.75, 0.83, and 0.80 respectively. To conduct the quasi-experiment, the regular chemistry teachers of the selected schools trained by the researcher were used for the study. The training lasted three weeks covering two hours per week to ensure uniformity and mastery of the teaching guide. Each teacher was given a copy of validated lesson plans and copies of the two instruments used for the study. The Scientific Literacy Test (SLT) and Chemistry Achievement Test (CAT) were administered as pre-test, but Scientific Literacy Test (SLT) was administered first to categorize students into high, medium and low levels of scientific literacy according to the specification given by the researcher before treatment commenced.

The main treatments for the study were taught using guided discovery and demonstration teaching methods, which lasted for a period of six weeks. The experimental groups were taught a chemistry concept (water) using the guided discovery method. This involved grouping the students into four or six with each group provided with instructional materials (salts, water beakers, etc) needed for the lesson. The teaching involved introduction of the topic, drawing attention to the instructional materials, using probing questions, student questioning and drawing conclusions on their own and the teacher directing/correcting student's inconsistencies. Each activity was followed by a class discussion. The control groups were taught the same concept using teacher demonstration

as teaching method. Here, the regular chemistry teacher delivered and demonstrated the pre-planned lessons to the students with little or no interaction and each entire class was taught as a single group. The students were supplied with the facts of the concepts; the students listened, observed and assimilated principles and procedures for the correct solutions to the problems. Immediately after the treatment, the Chemistry Achievement Test (CAT) was administered the second time to the students as a post-test and the scores were computed.

RESULTS AND DISCUSSION

Table 2: Pre-test and Post-test Mean Achievement and Standard Deviation (SD) scores of students in CAT due to Teaching Methods and Scientific Literacy Levels.

Teaching Method	Type of Test	Scientific Literacy Level					
		High		Medium		Low	
		Mean	SD	Mean	SD	Mean	SD
Guided discovery	Pre-test	24.34	12.91	23.00	17.81	15.13	7.09
	Post-test	57.64	14.03	44.51	21.02	32.51	15.45
Demonstration	Pre-test	33.60	19.23	18.10	17.22	16.62	15.45
	Post-test	49.73	17.75	38.08	11.43	31.56	20.69

Table 2 indicates that the two teaching methods have remarkable effect on student's levels of scientific literacy. When the guided discovery was used, the pre-test and post-test mean achievement scores 24.23 and 57.64 with SD of 12.91 and 14.03 respectively for the high level group. The medium level group had mean achievement scores of 23.00 and 44.51 with SD of 17.81 and 21.02 used, respectively. The low level group had a mean achievement scores of 15.13 and 32.21 with SD of 7.09 and 15.45 respectively. Therefore, for the guided discovery method, the higher the scientific literacy level, the higher the achievement of students in chemistry.

For the demonstration teaching method, the pre-test and post-test mean achievement scores were 33.60 and 49.73 with SD of 19.23 and 17.75 respectively for the high level group. For the medium level group the scores were 18.01 and 38.08 with SD of 17.22 and 11.43 respectively. The low level group scored 16.62 and 31.56 with SD of 15.45 and 20.69 respectively. These results also show that for the demonstration teaching method group, the higher the level of scientific literacy, the better the achievement of students in chemistry.

Table 3: Mean and Standard Deviation (SD) Scores of Students Achievement in Chemistry by Teaching Methods and Scientific Literacy Levels.

Teaching Method		Scientific Literacy Level		
		High	Medium	Low
Guided discovery	N	14	30	34
	Mean	1 8.41	16.57	15.37
	SD	13.13	21.51	13.37
Demonstration	N	24	20	23
	Mean	5.42	15.05	9.89
	SD	18.21	10.82	7.46

Table 3 indicates that for all levels of scientific literacy of students, the guided discovery method showed higher mean achievement scores on CAT than the demonstration teaching method. For the high level group the mean score is 18.41 with SD of 13.13 for the guided discovery method as against the mean score of 5.42 and SD of 18.21 for the

demonstration teaching method. The medium level group had a mean score of 16.57 and SD of 21.51 for guided discovery method as against a mean score of 15.05 and SD of 10.82 for the demonstration teaching method. The low level group had a mean score of 15.37 with SD of 13.75 for guided discovery method as: against a mean score of 9.89 and SD of 7.46 for the demonstration teaching method. These results indicate that the guided discovery method is superior to the demonstration method in producing higher mean achievement scores in chemistry for all level scientific literacy of students.

Table 4: Analysis of Covalence (ANCOVA) of students overall achievement scores by teaching method and scientific literacy levels.

Source of variation	sum of square	df	Mean	f	significant
Covariate					
Pre-test	5535.115	1	5535.115	37.012	0.0000
Main effects	2247.038	3	749.013	5.444	0.001
Teaching method	545.973	1	545.973	4.364*	0.036
Scientific literacy level	2118.539	2	1059.270	6.581	0.001
2-way interaction					
Teaching method x Scientific literacy level	201.537	2	100.769	0.621	0.389
Explained	14532.033	6	2422.066	18.033	0.000
Residual	18535.230	138	134.313		
Total	33067.263	144	229.634		

(*) denotes significant difference at 0.05 alpha level.

From table 4, the F-value for main effect of teaching method is 4.364 at 1 and 138 degrees of freedom (df) and is significant at 0.05 levels. Therefore, the null hypothesis of no significant difference is rejected. Hence, there is a significant difference between students taught chemistry using guided discovery and demonstration teaching methods. Since the difference in the mean achievement scores due to scientific literacy level is significant, a post-hoc multiple comparison test Scheffe procedure was further used to determine the direction of the difference. The result is presented in table 5.

Table 5: Post Hoc multiple comparison Test Between Three Mean Scores on Overall Achievement

Mean	Scientific Literacy Level			
		Low	Medium	High
31.885	Low			
41.295	Medium	*		
53. 685	High	*	*	

(*) = The mean difference is significant at 0.05 level.

The table 5 indicates that each level of scientific literacy differs significantly from the other in terms of achievement in chemistry when these two teaching methods were used. Thus the mean achievement scores of the low level group was significantly different from that of the medium and high level groups respectively, while that of the medium group differs significantly from that of high and low groups respectively. Table 4 reveals that the 2-way interaction between teaching methods and scientific literacy levels is 0.621 at 2 and 138 degrees of freedom. This value is not significant at the 0.05 levels. Therefore, the hypothesis of no significant interaction between teaching methods and scientific literacy

level is not rejected. Table 2 indicates that the guided discovery method produced the highest mean achievement score in chemistry for the high scientific literacy level group followed by the medium and low-level groups respectively. Similarly, the demonstration teaching method produced the highest mean achievement score in chemistry for the high level group followed by the medium and low scientific literacy level groups respectively. Results on Table 4 confirm that the differences in the mean achievement scores in chemistry among students in the three levels of scientific literacy are significant. An observed F-value of 6.581, F 0.05 (2, 138) = 3.96 indicates that the highest the scientific literacy level, the better the performance in chemistry for the two teaching methods. The findings of this study on Table 3 indicates that the guided discovery method is superior to the demonstration method in producing higher mean achievement scores in chemistry for all levels of scientific literacy students. The variety of teaching materials and the guidance provided to the learners during the learning process enable them not only to interact but also to understand the nature of the performance expected of them. They also provide appropriate channel for critical thinking and creative reasoning which are all traits of scientific literacy, hence the better performance.

CONCLUSION AND RECOMMENDATIONS

This study highlighted the effect of the guided discovery and demonstration teaching methods on achievement of chemistry students of different scientific literacy levels. The findings also indicate that the guided discovery method is superior to the demonstration method in promoting cognitive achievement in chemistry amongst students of all levels of scientific literacy level, the better the students' performance in chemistry for both teaching methods. Based on the findings of this study, three recommendations are made:

1. The government should encourage science teachers to use guided discovery method by providing needed conducive environment for teaching/learning and adequate instructional materials.
2. There is need for in-service training of science teachers to include how to use guided discovery method since most of the teachers are not acquainted with the use of such innovative teaching methods.
3. Science teachers should no longer be contented with teaching for acquisition of knowledge alone but should also teach for inculcation of scientific literacy.

REFERENCES

Abdullahi, A. B. (2007). Improving the teaching methods of Chemistry Practical STAN Chemistry Panel National Workshop Proceedings, (3), 120-123.

Adamu, A. (2001). Computer Assisted Teaching Learning NCCE Abuja Area Ltd. Kaduna.

Adeoye, N. and Alayande A. (2009) Use of Prediction and observe to explain the teaching of air. In N. S. Udofia and D. M. Dauda (Eds). Approaches to the teaching of living and non living things. STAN. Int. Science Education Series No. 8.

Akinsete, A. M. (2006) Effective method of teaching difficult concepts in chemistry. Chemistry Panel STAN Workshop. Series 2, 47-54

Arons, A. B. (1983). Achieving winder scientific literacy. *Journal of Research in Curriculum*, 112(2), 9-122

Eze, C. U. (2003). An investigation into the scientific literacy levels of Non science students of Nigeria Universities: A case study of University of Nigeria, Nsukka. *Journal of Science Teachers Association of Nigeria*, 38, (1 & 2), 51-57

Federal Republic of Nigeria (2004) National Policy on Education. Lagos: NERDC Press.

Ibe, E. (2004), Effects of guided-inquiry and demonstration on science process skills acquisition among biology secondary school students. Unpublished M.Ed Thesis, University of Nigeria, Nsukka.

Madu, B. C. (2004). Effect of a constructivist-based instructional model on Students' conceptual change and retention in physics. Unpublished Ph.D Thesis, University of Nigeria, Nsukka.

Nbina, J, B. & Arokuyu A. A. (2009). Using demonstrations to promote students' comprehension in chemistry. *Nigerian journal of empirical studies in psychology and educational* (NJESPE) 1 (10) 88-95

Nbina J. B. & Obomanu B. J. (2011). Assessment of the effects of problem solving instructional strategies on students' achievement and retention in chemistry with respect to location in Rivers State. World Journal of Education, 1 (2) 74-79

Nnaobi, A. F. (2007), Teaching qualitative inorganic component analysis in Colleges using multiple methods. *Journal of Science Teacher Association of Nigeria*, (3), 87-91.

Nwachukwu, J. N. & Nwosu, A. A. (2007) Effects of demonstration method of different levels of students' cognitive achievement in senior secondary school biology. *Journal of Science Teacher Association of Nigeria* (1 & 2), 50-59.

Shaleigh, O. (2004). How chemistry teachers in Makurdi teach: An observational study. Unpublished B.Ed Project, Benue State University, Makurdi, Nigeria.