EFFECT OF PROBLEM-BASED LEARNING STRATEGY ON THE ACADEMIC ACHIEVEMENT AND RETENTION OF SSII CHEMISTRY STUDENTS IN CALABAR EDUCATION ZONE

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Abstract
This study investigated the effect of problem-based learning (PBL) on the academic achievement and retention of concepts among SSII chemistry students in Calabar Education Zone. The study adopted the pre-test, post-test control group, quasi-experimental research design. The sample for the study consisted of 124 senior secondary school II chemistry students selected by stratified random sampling from six schools in Calabar Education Zone of Cross River State. The experimental group comprised of 60 students taught using problem-based learning strategy while the control group comprised of 64 students taught using the conventional method. Two research hypotheses were formulated and were tested using Analysis of Covariance and Multiple Classification Analysis. The data was collected using a researcher-made Chemistry Achievement Test and Chemistry Retention Test. The result of data analysis revealed that PBL increased students' academic achievement and students' retention of concepts in chemistry more than the conventional method of teaching, It is, therefore, recommended that chemistry teachers should adopt PBL for effective teaching and learning of chemistry and that chemistry teachers be trained on the use of PBL.

Introduction

One of the basic roles of teachers is to bring about desired change in learners. Teachers are saddled with the responsibility of passing the knowledge that learners need for survival. Since advancement in science and technology leads to national development, science teachers are expected to produce students of high performance standard that will contribute to national development. Chemistry, being one of the major ingredients of technology, must be taught effectively to transfer the necessary skills, attitudes and knowledge that will enable learners to contribute their quota to national development.

To do so, teachers must demonstrate certain skills and proficiencies in teaching. The educational system in Nigeria today is challenged by the problem of poor performance of students in chemistry examinations. The Federal Government of Nigeria has made efforts to promote chemistry teaching and learning in our secondary schools by employing more chemistry teachers and sending them for in-science training and by even providing science equipment. In spite of these efforts, chemistry achievement is still in a deplorable state. This is supported by West African Examination Council (WAEC) Chief Examiner's report (2010-2014) which revealed that students' performance in WAEC examination in chemistry is consistently poor. Some educators attribute the poor performance of students in chemistry to the poor background knowledge of students in Basic Science that was taught in their junior secondary school classes (Olatoge and Atuwape, 2004). Some others blamed the poor achievement in chemistry to the methods used

by teachers in presenting concepts in chemistry (Otor, 2013 and Jack, 2013).

Most secondary schools' chemistry teachers adopt conventional expository method of teaching which has rendered our students passive and encouraged rote memorising rather than meaningful learning (Egbo, 2014). There is, therefore, the need for students to be introduced to teaching strategies and methods that will encourage their participation. This will arouse the interest of the students. Such teaching strategies which the teacher can use to transform his/her classroom into an exciting/ suitable learning environment to promote meaningful learning and retention of basic chemistry concepts include concept mapping and problem-based learning.

Problem-based learning (PBL) is a teaching strategy in which students try to solve a problem or a set of problems that are not familiar to them. It is a constructivist based approach that promotes active learning (Cowan, 2019). Problem-based learning promotes self-directed learning, communication and collaboration skills as students work in their small groups. Group work helps students to form learning communities that will encourage them to develop new ideas, raise questions about the issue under consideration in a relaxed manner. Students find teamwork interesting and motivating because they get actively involved in the process and are held accountable for their actions by group members (Cohen, 1994).

Klegeris and Human (2011) posits that the entire process of PBL is very interactive and has been shown to improve retention and satisfaction. Akubilo stressed that any instructional strategy which elicits adequate students' interaction has a great effect on students' understanding and retention of concepts. A number of studies have affirmed this stand. Kaeser, Kamper and Hawk (2014) compared the effect modified PBL has on retention of concepts in two groups of medical students and found that the group that was able to interact with patients during clinical simulation scored statistically higher on both achievement test and retention test. A study carried out by Anderson (2007) also revealed that students in the teacher-guided learning group learnt the information at a more shallow level and could not retain much of what was learnt as their counterparts in the problem-based learning group. A study carried out by Gurr (2011) on project-based learning PBL and traditional lecture teaching method showed that PBL group performed significantly better in long term retention and soft skills acquisition than the teacher-guided group. Zakariya, Ibrahim & Adisa (2016) studied the impacts of PBL on academic performance and retention in mathematics among junior secondary school students in Sabon-gari Area of Kaduna State – Nigeria using pretest, posttest and post-post test, quasi-experimental, non-equivalent control and experimental groups. The result of their analysis showed that there was significant mean difference between the performance of students exposed to PBL and those exposed to traditional method in favour of those taught using PBL and no significant difference in their post-posttest for retention. Charif (2010) investigated the effect of problem-based learning on students' performance and attitude towards chemistry among 7^{th} grade students in Lebanon private school. The study adopted a pre-test post-test research control group model. The result of his data analysis revealed that students taught using PBL approach had improved academic achievement and attitude towards chemistry.

Despite the effectiveness of PBL approach to instruction as reported in the literature, only very few studies were carried out in Nigeria. Fewer or no study had been reported on the effect of PBL on achievement and retention of chemistry concepts among senior secondary (SSII) chemistry students in Calabar Education Zone.

This study, therefore, was aimed at determining the effects of problem-based learning on the academic achievement and retention of concepts in chemistry among SSII chemistry students in Calabar Education Zone.

Research hypotheses

The following null hypotheses were formulated and tested:

H_{o1}: There is no significant effect of treatment on students' academic achievement in chemistry.
H_{o2}: There is no significant effect of treatment on students' retention of concepts in chemistry.

Research method

The study adopted a quasi-experimental, pre-test/post-test control group design. The population for the study comprised all senior secondary two chemistry students in Calabar Education Zone of Cross River State.

Six separate intact classes selected by stratified random sampling technique were randomly assigned, three each to the experimental and control groups respectively. A total of 126 senior secondary II chemistry students drawn from six co-educational secondary schools in Calabar Education Zone of Cross River State were the subjects for the study.

The instrument for data collection were researcher-made Chemistry Achievement Test (CAT) and Chemistry Retention Test (CRT). The instruments were face and content validated by two experienced chemistry teachers from two different secondary schools in Calabar and an expert in measurement and evaluation from the University of Calabar. The reliability of the study instruments was ascertained using Kuder Richardson formula 20 (KR-20). The internal consistency index obtained from CAT and CRT using KR-20 was 0.78.

The data obtained using CAT and CRT were analysed using analysis of covariance (ANCOVA) and Multiple Classification Analysis (MCA).

Procedure

The instructional methods used for the study were problem-based learning (PBL) strategy and the conventional method of teaching. PBL was used to teach the experimental group while conventional method was used to teach the control group. Chemistry teachers in the sampled schools were used as research assistants and were trained for one week by the researcher on the use of the instructional methods with the prepared lesson notes on the two teaching methods. A uniform instruction was given and the teachers took turns to teach, demonstrating their abilities and skills on the use of the instructional methods while the researcher gave the required corrections. The teachers were then given the necessary instructional packages that will enable them to effectively undertake the teaching.

For PBL strategy, the teacher gave a mini-lecture on the topic, then he presented the students with an ill-structured problem to resolve or a scenario was presented from which the students were to find reasons and explanations to the occurrences that were presented. The students in their small groups find solutions to problems and answer questions. They checked textbooks, browsed the net, related known and new concepts, made generalisations and arrived at solutions while the teacher served as a guide/facilitator. In the conventional method, the teacher gave a detailed explanation of concepts to be learnt with examples to the students while the students paid attention and asked questions where they needed clarification. The teaching period lasted for three weeks and took place simultaneously in the six schools. The classes were held twice a week and each lesson lasted for forty minutes. The topics in thermochemistry include: Energy and forms of energy, exothermic and endothermic reactions. Before the commencement of teaching, a pre-test was administered to both groups. The result of the pre-test using analysis of variance, indicates that there is a statistically significant difference between the experimental and control groups in their pretest scores. Thus, the two groups were not equivalent before the administration of treatment. At the end of the teaching period, a post test was administered to test the instructional effectiveness of the methods. Six weeks later, a retention test was administered to determine the amount of content materials the students were able to retain after a period of six weeks. Data collected from pretest, posttest and retention test from the two groups were used to test the hypotheses.

Result and findings

There is no significant effect of treatment on students' academic achievement in chemistry. To test this hypothesis, analysis of covariance was applied to the data.

The result is presented in table 1, which shows that there is a significant effect of treatment (F_2, 123= 332.808 P < .05) on achievement. This result indicates that experimental and control groups differ significantly from each other in academic achievement. On the basis of this result, hypothesis 1 is rejected. To show the direction of difference, multiple classification analysis was applied to the data (see table 2). The result indicates that the adjusted mean scores for the experimental group and control group are 27.15 and 23.52 respectively, suggesting that the experimental group performed significantly better than the control group. The result also shows that a beta value of 0.888 for treatment effect was obtained, suggesting that treatment accounted for only 88.8 percent of variance of scores on post-test measure.

Table 1
Summary of analysis of covariance on post test scores according to treatment

Source of variance	Sum of squares	Df	Mean square	F-ratio	P- Level
Intercept	5656.390	1	5656.390	6175.810	.000
Pretest	57.133	1	57.133	62.379	.000
Treatment	609.628	1	304.812	332.804	.000

Model goodness of fat R = .891; R squared = 792

Table 2
Summary of multiple classification analysis on post-test scores according to treatment

Variables	Groups	N	Unadjusted mean	Adjusted mean	Eta	Beta
Treatment	Exp. Grp	60	27.16	27.15	.636	1888
	Control	64	23.52	23.52		

Hypothesis two:

There is no significant effect of treatment on students' retention of concepts in chemistry. To test this hypothesis, analysis of covariance was applied to the data. The result is presented in table 3.

Table 3 shows that there is significant effect of treatment (F_2 123 = 47.033, P < .05) on retention. This result indicates that experimental and control groups differ significantly from one another in retention. On the basis of this result, hypothesis 2 is, therefore, rejected. To show the direction of difference, multiple classification analysis was applied to the data (see table 4). The result indicates that the adjusted mean scores for the experimental group and control group are 26.90 and 13.85, suggesting that the experimental group performed significantly better than the control group. The result also shows that a beta value of .910 for treatment effect was obtained, suggesting that treatment accounted for only 9.10 percent of variance of scores on retention measure.

Table 3
Summary of analysis of covariance on retention-test scores according to treatment

Source of variance	Sum of squares	Df	Mean square	F-ratio	Sig.
Intercept	152.949	1	152.949	37.776	.000
Post-test	547.210	1	547.210	135.154	.000
Treatment	380.851	1	190.426	47.033	.000

Model goodness of fit r - .913, R Squared = .8333

Table 4
Summary of MCA on retention-test scores according to treatment

Variables	Groups	N	Unadjusted mean	Adjusted mean	Eta	Beta
Treatment	Exp. Grp	60	26.95	26.90	.903	.910
	Control grp	64	13.85	13.85		

Model good of fit R = .913, R squared = .833

Discussion of the findings

Effect of teaching method on students' academic achievement in chemistry. The result of data analysis of the first hypothesis indicates that SSII chemistry students taught chemistry using problem-based learning strategy performed significantly better than their counterparts in the control group taught using the conventional method.

This is in agreement with the work of Charif (2010), Zakariya, Ibrahim & Adisa (2016) and Kaeser, Kamper & Hawk (2014) which revealed that the use of problem-based learning in teaching and learning promotes understanding of concepts and consequently lead to higher academic achievement among learners.

The result of data analysis of hypothesis two indicates that students taught chemistry using PBL performed significantly better than those taught using the conventional method in the post-test for retention of concepts. Implying that students taught using problem based learning were able to retain most of the learnt material than those taught using the conventional method. This is in consonance with the study carried out by Gurr (2011), Kaeser, Kamper & Hawk (2014) and Anderson (2007) who found that PBL strategy is effective for long term retention of learnt material. The findings of this study is suggestive of the fact that problem-based learning stimulates creative thinking in students and hence induces learning. Students were able to learn meaningfully as they were actively involved in the learning/teaching processes; hence, they were able to retain what was learnt unlike the conventional method which did not encourage intuitive and systematised learning.

Conclusion and Recommendations

Based on the findings of the study, it was concluded that problem-based learning leads to meaningful learning of chemistry concepts with high academic achievement and retention of concepts learnt; therefore, it should be adopted by chemistry teachers. The conventional method is not an effective method of teaching, hence it should be complemented with other methods.

In view of the findings of this study, the following recommendations are hereby put forward:

1. Problem-based learning should be adopted for effective teaching of chemistry in secondary schools and should be prescribed by examination bodies and curriculum designers in their syllabuses for the teaching of chemistry.
2. The State Ministry of Education and School Administrators should organise seminars, workshops and retraining

programmes to educate chemistry teachers on the use of PBL for effective teaching and learning of chemistry.

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