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EFFECTS OF PROBLEM-BASED LEARNING INSTRUCTIONAL STRATEGY ON ACADEMIC ACHIEVEMENT OF SENIOR SECONDARY SCHOOL STUDENTS IN CHEMISTRY IN IMO STATE, NIGERIA

Cliff I. Okebanama, Catherine U. Ene & Roseline I. Ezechukwu

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Abstract

This study investigated the effect of Problem-Based Learning instructional strategy on academic achievement of secondary school students in chemistry. Pre-test post-test quasi experimental research design was adopted in the study. This study was carried out in Obowo L. G. A., Imo State. A sample of eighty nine (89) Senior Secondary two (SS II) students selected by simple random sampling technique from seven public co-educational secondary schools in Obowo LGA in Okigwe Education Zone II, Imo State took part in the study. The instrument for data collection was Chemistry Achievement Test (CAT) with a reliability index of 0.82. The reliability index was established using Kuder-Richardson Twenty formula (K-R_{20}) after a pilot study was conducted. Two research questions and two null hypotheses guided the study. Research questions were answered using mean and standard deviation while Analysis of Covariance (ANCOVA) was used in testing the two hypotheses at .05 level of significance. Findings showed that students who were taught chemistry using Problem-Based Learning Instructional Strategy achieved significantly better than the control group taught using lecture method. Furthermore, the findings of the study revealed that male students exposed to Problem-Based Learning Instructional Strategy achieved significantly higher than their female counterparts. Recommendations were made which include among others that chemistry teachers should adopt the use of Problem-Based Learning Instructional Strategy to improve academic achievement in secondary school chemistry.

Key words: *Chemistry, Achievement, Problem-Based Learning Instructional Strategy.*

Introduction

Science is the foundation upon which the bulk of present-day technological breakthroughs are built. Nations all over the world are striving hard to develop technologically and scientifically, since the world is turning scientific and all proper functioning life depends on science. Science is a great enterprise which nations depend on, in order to advance technologically. Science therefore is receiving much emphasis in education because of its significance and relevance to life and society. Science education plays a very important role in the development of a nation's knowledge base and economy. Every nation needs to equip her citizenry with adequate scientific knowledge and skills to be able to compete favourably globally. Science education is concerned with providing a nation with scientifically literate people capable of making rational conclusions. It is an attainment of the goal of science education that the required large pool of experts in science and technology are produced which will help to bring about the much needed socioeconomic development of the nation. The importance of science in our society made the Federal Government of Nigeria to introduce science subjects in the nation's secondary school curriculum. These courses include Physics, Biology, Life Science, Chemistry etc.

Chemistry education occupies a pivotal position in science education. According to Giginna and Nweze (2014), the enviable position which Chemistry occupies in the

educational system of most countries of the world including Nigeria is perhaps, justifiable in the sense that chemistry can exert a dominant if not a decisive influence on the life of individuals in the areas of industry, agriculture, infrastructure as well as in the developmental effort of a nation. Eze and Obiekwe (2018) viewed chemistry education as a necessary ingredient for becoming self-reliant, earning a living and contributing towards building a sustainable national development. Nwaka, Egbo and Okechineke (2016) asserted that there is virtually no process of production which does not involve one aspect of chemical process or the other. Chemical principles are employed in oil refineries, petrochemical industries and in the manufacture of soaps, dyes, cosmetics, nylon, glass, plastics, drugs and pesticides.

In spite of the importance of Chemistry in national development, researchers have observed low achievement among chemistry students in senior secondary school certificate examinations (Giginna & Nweze, 2014; Aniodoh & Eze, 2014; Ellison, 2007). Chief examiner's report 2016-2021 indicated poor achievement of chemistry students in WASSCE and NECO. The poor achievement of students in chemistry has been blamed on some factors like unqualified chemistry teachers, inadequate chemistry teachers, use of inappropriate teaching methods, abstractness of chemistry, lack of in-service training among others (Giginna and Nweze, 2014). According to Ibrahim (2011), teachers hold the key to the door of scientific and technological knowledge and are therefore undisputedly the ultimate determinant of national development and survival. Afe (2002) asserted that the realization of the best educational polices, curricular design and expenditure of colossal sum of money depends on the teachers because they are responsible for translating policy into action and principles into practices in their interactions with students in their programmes. Afe (2002) further stated that for the teacher to be functional and effective in his/her delivery, he/she should be knowledgeable both in content and pedagogy. Eze and Obiekwe (2018) opined that students' interest in learning chemistry could be enhanced by chemistry teachers through careful choice of the most appropriate teaching methods. Okoye (2014) asserted that teaching and learning have gone beyond the teacher standing in front of the learners to disseminate information to them without learners actively participating.

However, literature is replete with evidence that chemistry classrooms are dominated with conventional methods of teaching which make students passive recipients in the teaching/learning process. For example, Giginna and Nweze (2014) blamed the poor achievement in chemistry on poor teaching strategies adopted by chemistry teachers over the years. Chemistry as a subject is not only abstract but volatile and requires to be taught by using a variety of teaching strategies so as to ensure that the learners have a good understanding of the concepts. According to Njelita (2015), the use of one instructional strategy is capable of making teaching boring to students and their interest greatly reduced. Eze and Obiekwe (2018) observed that the conventional (lecture) method commonly used in teaching chemistry in Nigeria is boring and uninteresting. Uzoechi (2014) stated that science education (chemistry inclusive) programmes must focus attention on innovative teaching methods that can promote creative thinking in scientific problem-solving. Science educators advocate a shift from teacher-centred methods to learner-centred methods that engage students actively in the process of learning. Prominent among such learner-centred methods is problem-based learning instructional strategy.

Problem-Based Learning (PBL) instructional strategy is a learner-centered pedagogy in which students learn about a subject through the experience of solving an open-ended question. PBL presents students with a real-world issue on a subject and asks them to come up with a well-constructed answer. They can tap into online resources, textbooks, use their previously-taught knowledge, and ask critical questions to brainstorm and present a solid solution. Problem-based learning instructional strategy is a cooperative learning strategy that belongs to the group of strategies called inquiry-based learning strategy. The process of PBL commences with the teacher giving out a problem or asking an open-ended question to

which there may be a variety of answers. There are basically seven steps involved in PBL instructional strategy. *Nilson, (2010)* enumerated these steps as follows:

Step 1: Problem Definition: The problem is defined in the form of one or more questions.

Step 2: Clarifying Unfamiliar Terms: Unclear terms in the problem description are clarified, so that every group member understands the information that is given.

Step 3: Brainstorm: The preexisting knowledge of group members is activated and determined. This process entails the generation of as many explanations, ideas and hypotheses as possible. The ideas of all group members are collected, without critical analysis.

Step 4: Analyzing the Problem: Explanations and hypotheses of the group members are discussed in depth and are systematically analyzed. Ideas from the brainstorm are ordered and related to each other.

Step 5: Formulating Learning Goals: Based on contradictions, obscurities, and ambiguities from the problem analysis, questions are formulated that form the foundation for the study activities of the group members. In short, it is determined what knowledge the group lacks, and learning goals are formulated on these topics.

Step 6: Self-Study: In the self-study phase, group members search for relevant literature that can answer the questions in the learning goals. After studying this literature, group members prepare themselves for reporting their findings in the next tutorial meeting.

Step 7: Reporting: After reporting what sources group members have used in their self-study activities, a discussion of the learning goals takes place based on the studied literature. Group members try to synthesize what they have found in different sources.

These seven steps are coordinated by a group leader which is selected by group members irrespective of gender. According to Eze and Obiekwe (2018), gender is a socially ascribed attribute which differentiates males from female. Gender is a cultural construct that distinguishes the roles, behaviour, mental and emotional characteristics between males and females developed by a society (Giginna & Nweze, 2014). The influence of gender on students' achievement in science in general and chemistry in particular has been a global concern to science educators and researchers. Unfortunately, the findings are contradictory. Whereas some researchers found a significant difference in the achievement of male and female students in chemistry (Giginna & Nweze 2014; Aniodoh & Eze, 2014); others found no significant difference in the achievement of male and female students in the subject (Fatokun, Egya & Uzoechi, 2016). Conflicting results as reported above necessitated further investigation in the area of gender especially in problem-based learning instructional strategy.

Many researches have been carried out on the effect of some cooperative learning instructional strategies like think-pair-share, blended learning etc. but there is little or no research that is centered specifically on problem-based learning instructional strategy on students' achievement in the area of chemistry education. For instance, Eze and Obiekwe, (2018) carried out research on think-pair-share instructional strategy: a variety tool for enhancing students' achievement in secondary school chemistry and discovered a significant improvement in students' achievement in chemistry as compared to lecture method. This significant improved achievement is in favour of the experimental group (Think-pair-share). They attributed their findings to the interesting nature of the instructional technique. Moreso, Mbonu, (2018) investigated the comparative effects of blended and non-blended learning strategies on students' achievement in basic science and discovered a significant increase in students achievement in basic science in favour of blended learning instructional strategy. The researcher concluded that learning with mix of digital resources and face-to-face classroom instruction enhanced the achievement of students better than those taught with just face-to-face classroom instruction. Because of insufficient research in problem-based learning instructional strategy on students' achievement in the area of chemistry education and poor academic achievement of students in chemistry internal and external examinations; there is

need to carry out research to check if problem-based learning instructional strategy can proffer solution to the recurrent poor achievement of secondary school students in both internal and external examinations in chemistry. This study therefore investigated the effect of problem-based learning instructional strategy on academic achievement of senior secondary school students in chemistry.

Research Questions

The following research questions guided the study:

1. What are the mean achievement scores of students taught chemistry using Problem-Based Learning instructional strategy and those taught with lecture method?
2. What are the mean achievement scores of male and female students taught chemistry using Problem-Based Learning instructional strategy?

Hypotheses

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

H_{01}: There is no significant difference in the mean achievement scores of students taught chemistry using Problem-Based Learning instructional strategy and those taught with lecture method.

H_{02}: There is no significant difference in the mean achievement scores of male and female students taught chemistry using Problem-Based Learning instructional strategy.

Methods

The study adopted a quasi-experimental research design, specifically, pretest-post-test non-equivalent control group. The study was conducted in Okigwe Education Zone II of Imo State, Nigeria. Purposive sampling technique was used to sample Okigwe Education Zone II. Okigwe Education Zone II was purposively selected because of insecurity in the other zones of Imo State at the time of this study. Okigwe Education Zone II is made up of three local government areas namely: Ihitte/Uboma, Ehume Mbano and Obowo local government areas. Obowo local government area was drawn and used for this study using simple random sampling technique. The population for the study comprised all the one thousand and twenty nine (1,029) SS II students offering Chemistry in the seven public co-educational secondary schools in Obowo LGA in 2021/2022 session. Since gender was a moderator variable in the study, two co-educational secondary schools were sampled from the seven public co-educational secondary schools in Obowo LGA using simple balloting. The two co-educational schools were assigned to experimental and control groups using simple balloting. SS II (Science Class) intact classes in the schools were used. This gave rise to forty six (21 males and 25 females) and forty three (19 males and 24 females) students in the experimental and control groups respectively. The total sample for the study was eighty nine (89) SS II Chemistry students.

The instrument for data collection was Chemistry Achievement Test (CAT) made up of forty (40) item multiple choice questions. The items in the instruments were adapted from West African Senior Secondary Certificate Examination (WASSCE) past question. The instrument was face validated by three experts in Science Education from University of Nigeria, Nsukka. To ensure the content validity of the instrument, a test blue print was used in adapting the question items. The reliability index of the instrument was established to be 0.82 using Kuder-Richardson Twenty ($K\text{-}R_{20}$) after a pilot study was conducted outside the local government used for the study. The regular chemistry teacher of the experimental group was trained on how to use problem-based learning instructional strategy and was used for the study. The study lasted for six (6) weeks. The pre-test was administered to both the control and experimental groups on the first week. The treatment commenced thereafter and lasted for four (4) weeks. After the treatment, the post-test was administered to both the control and experimental groups. The scripts were marked and scores collated. Each correctly answered question was scored two marks. Failed questions were scored zero mark. The two research questions were answered

using mean and standard deviation while the two null hypotheses were tested at .05 level of significance using Analysis of Covariance (ANCOVA).

Results

Research Questions One: What are the mean achievement scores of students taught chemistry using Problem-Based Learning instructional strategy and those taught with lecture method?

Table 1: Mean Achievement Scores of Students Taught with PBL Instructional Strategy and Lecture Method

Techniques	N	Pre-Test Mean	Post-Test Mean	Gain Scores	SD of Pre - Test	SD of Post - Test
PBL	46	31.96	67.39	35.43	10.78	13.71
Lecture Method	43	37.12	45.72	8.60	10.06	12.80
Difference		5.16	21.67	26.83		

Table 1 showed the pre-test and post-test mean scores of students taught chemistry with PBL instructional strategy to be 31.96 and 67.39 respectively with a gain score of 35.43. This showed that learning actually took place. Similarly, the table revealed the pre-test and post-test of students taught chemistry with lecture method to be 37.12 and 45.72 respectively with gain score of 8.60. This also indicated that learning actually took place. The table also indicated a reasonable mean score difference in the post-test of the two groups as 21.67 with higher mean in favour of PBL instructional strategy. This implied that students taught chemistry with PBL instructional strategy learnt more or achieved better than the other group.

Research Question Two: What are the mean achievement scores of male and female students taught chemistry using Problem-Based Learning instructional strategy?

Table 2: Mean Achievement Scores of Male and Female Students Taught with PBL Instructional Strategy

Gender	N	Pre-Test Mean Scores	Post-Test Mean Scores	Gain Scores	SD of Pre-Test	SD of Post-Test
Male	21	32.10	76.00	43.90	10.87	5.72
Female	25	31.84	60.16	28.32	10.92	14.34
Difference		0.26	15.84	15.58		

Table 2 showed the pre-test and post-test mean achievement scores of male students taught chemistry with PBL instructional strategy to be 32.10 and 76.00 respectively with a gain score of 43.90. This also showed that learning took place. The table also showed the pre-test and post-test scores of the female students taught with PBL instructional strategy to be 31.84 and 60.16 respectively with a gain score of 28.32. This equally showed that learning took place. However, the difference in male and female pre-test mean score (0.26) tend to suggest that the male and female students appeared to have the same level of knowledge on what they were to learn before the experiment while the higher difference in the post-test mean score (15.84) in favour of the male suggested that the male students may have learnt better than their female counterparts when taught chemistry with PBL instructional strategy.

Hypothesis One: There is no significant difference in the mean achievement scores of students taught chemistry using Problem-Based Learning instructional strategy and those taught with lecture method.

Table 3: Analysis of Covariance on the Mean Achievement Scores of Students Taught Chemistry with PBL Instructional Strategy and Lecture Method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10558.951[a]	2	5279.476	29.852	.000	.410
Intercept	26678.581	1	26678.581	150.850	.000	.484
Pretest	122.109	1	122.109	.690	.408	.001
Technique	9299.800	1	9299.800	52.584	.000	.396
Error	15209.498	86	176.855			
Total	314132.000	89				
Corrected Total	25768.449	88				

a. R Squared = .410 (Adjusted R Squared = .396)

Table 3 showed the **analysis of covariance on the mean achievement scores of students taught chemistry with PBL instructional strategy and lecture method. Table 3 showed** that the F-ratio is 52.584 with 1 degree of freedom. Since the associated alpha level of .000 is less than the chosen p-value of .05 ($p < 0.05$), the null hypothesis is rejected. This implies that there is a significant difference in the mean achievement scores of students taught chemistry using Problem-Based Learning instructional strategy and those taught with lecture method.

Hypothesis Two: There is no significant difference in the mean achievement scores of male and female students taught chemistry using Problem-Based Learning instructional strategy.

Table 4 : Analysis of Covariance on the Mean Achievement Scores of Male and Female Students Taught Chemistry with PBL Instructional Strategy.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3298.274[a]	2	1649.137	13.752	.000	.390
Intercept	27483.161	1	27483.161	229.174	.000	.731
Pretest	434.678	1	434.678	3.625	.064	.035
Gender	2889.860	1	2889.860	24.098	.000	.362
Error	5156.682	43	119.923			
Total	217368.000	46				
Corrected Total	8454.957	45				

a. R Squared = .390 (Adjusted R Squared = .362)

Table 4 showed the analysis of covariance on the mean achievement scores of male and female students taught chemistry with PBL instructional strategy. Table 4 showed that the F-ratio is 24.098 with 1 degree of freedom and .000 significant level. Since the associated alpha level of .000 is less than the chosen p-value of .05 ($p<0.05$), the null hypothesis is rejected. This implies that there is significant difference in the mean achievement scores of male and female students taught chemistry using Problem-Based Learning instructional strategy.

Discussions

The findings of this study showed a significant difference in the mean achievement scores of students taught chemistry with problem-based learning instructional strategy and those in the control group taught using

lecture method. The difference was in favour of the experimental group (PBL). This finding is in agreement with the findings of Rotimi, Ajogbeje, Akeju and Simpson, (2012), Ifamuyiwa and Onakoya (2013), Nwaubani, Ogbuegbu, Adeniyi and Eze (2016) who in their independent studies found significant differences in the mean achievement scores of students exposed to cooperative learning strategies like problem-based learning instructional strategy, visual-model instructional strategy, blended learning instructional strategy and think-pair-share instructional strategy than those taught using lecture method in favour of cooperative learning strategies. This agreement could be because cooperative learning strategies like problem-based learning instructional strategy engages the students during lesson delivery provides diverse views of a particular concept, appeals to the senses of the learners and promotes concretization of perceived difficult and abstract concepts. The findings of this study contradicts that of Anyamene, Nwokolo, Anyachebelu and Anemelu (2012) who discovered no significant difference in the mean achievement scores of students when taught mathematics using Problem-Based Learning instructional strategy and lecture method.

The findings of this study also revealed a significant difference in the mean achievement scores of male and female students exposed to problem-based learning instructional strategy in favour of the male. This finding is in tandem with Nwaubani, Ogbuegbu, Adeniyi & Eze (2016) who found out a significant difference in the achievement of male and female students when exposed to cooperative learning strategy. This implies that teachers need to ensure that both male and female are given appropriate attention to ensure equity in the classroom. However, this research contradicts that of Oludipe, (2012), Akunle (2015) who found out that there was no significant difference in the mean achievement scores of male and female students in science subjects. Also, the findings of this study is in disagreement with that of Ajai and Imoko (2015) who carried out a study to assess gender difference in Mathematics achievement using Problem-Based Learning. Ajai and Imoko found that male and female students taught algebra using PBL did not significantly differ in achievement, thereby revealing that male and female students are capable of competing and collaborating in Mathematics.

Conclusion

This study has confirmed that the use of problem-based learning instructional strategy improved significantly students' achievement in senior secondary chemistry than when taught with conventional method (lecture method). This also confirms that deploying PBL instructional strategy in teaching chemistry in secondary schools will improve academic achievement in chemistry. The findings also revealed that gender significantly influenced students' achievement in chemistry in favour of the male students.

Recommendations

The following recommendations were made:

1. Secondary school teachers should adopt the use of problem-based learning instructional strategy as a panacea for poor academic achievement in chemistry.
2. Curriculum planners should incorporate problem-based learning instructional strategy into the curriculum of pre-service teachers.
3. Curriculum planners should plan the curriculum in such a way that enough time is given for problem-based learning instructional strategy.
4. Chemistry teachers should give remedial training to the female students on innovative strategies like problem-based learning instructional strategies. This will make them square up with their male counterparts in the classroom.

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