EFFECT OF PROBLEM-BASED LEARNING STRATEGY ON SENIOR SECONDARY STUDENTS' ACHIEVEMENT AND INTEREST IN CHEMICAL EQUILIBRIUM IN ANKPA LOCAL GOVERNMENT AREA, KOGI STATE, NIGERIA

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Abstract

The study examined the effect of problem-based learning strategy on students' academic achievement and interest in chemical equilibrium. The study was quasi-experimental research which specifically used the pretest, posttest non-equivalent control group design. The target population of the study was 2, 996 (1210 males and 1786 females) Senior Secondary Schools II chemistry students for 2021/2022 academic session in all 57 secondary schools in Ankpa LGA of Kogi State. A sample of 62 *(35 males and 27 females)* SS II students from two secondary schools purposively taken in the study area. Four research questions and four hypotheses guided the study. Chemical Equilibrium Achievement Test (CEAT) and Chemical Equilibrium Interest Scale (CEIS) were instruments used for data collection. The instruments were validated by experts and pilot tested. A reliability coefficient of 0.85 was obtained for CEAT using Kuder-Richardson's K-21 and 0.72 for CEIS using Cronbach Alpha. Descriptive statistics of mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the research hypotheses at 0.05 alpha level of significance. Findings of the study revealed that problem-based learning strategy significantly enhanced students' achievement and interest scores in chemistry more than the conventional teaching method. Also, gender and interest have no influence on the academic achievement of students exposed to problem-based learning strategy. Based on the findings, it was recommended *among others that* chemistry teachers should be encouraged to adopt problem-based learning strategy in teaching chemistry concepts during their instructional practices.

Keywords: Achievement, Chemical Equilibrium and Gender, Interest, Problem-Based Learning Strategy,

Introduction

The objectives of chemistry education at the senior secondary school level include: to show chemistry and its link with industry, everyday life benefits and hazards, and to provide a course which is complete for individuals not proceeding to higher education (Federal Ministry of Education, 2013). Chemistry is a science springing from the principles of physics with its applications in other sciences such as life-sciences, engineering, technology, earth sciences and medicine (Abanikannda, 2016). Emmanuel (2013) sees chemistry education as the vehicle through which chemical knowledge and skill reach the people who are in need of capacities and potentials for development. In addition, Emmanuel further views that, chemistry education helps to address the social objectives of substance development as education is the primary means for empowerment, participation, cultural preservation, social mobility and equity. According to Ibe, Obikezie and Chikendu (2021), the study of chemistry is needed to develop the necessary skills, intellectual and mental training needed to observe measure and apply scientific attitude and skill towards natural phenomena that include the eagerness to learn and the ability to think critically. Despite the relevance of chemistry, the students' academic achievement in senior secondary schools in Nigeria has been very low and unimpressive (Salami, Mohammed, Ogunlade, Ayinla, 2012; Giginna & Nweze, 2014 and Uchegbu, Ahuchaogu & Amanz, 2017).

This was further proved from the analysis made by WAEC Chief Examiners' report (WAEC, 2018), that the performance of students in chemistry from 2007 to 2018 keeps in fluctuating. Available records show that, percentages of students that scored A1 to C6 grade are 44.16%, 44.47%, 44.49%, 50.7%, 49.54%, 43.1%, 72.34%, 62.49%, 60.6%, 57.74%, 62.68% and 61.95% respectively. It is very clear that general performance of students has not been excellent. It was only in the year 2013 that the percentage performance is above 70%. A good percentage of students failed chemistry and this is tantamount to drop in science related

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professions. Furthermore, WAEC Chief Examiners' report further pointed out that Chemistry students have poor knowledge of acids, bases and acid-base reactions and are unable to report results of acid-base titration experiments, unable to make calculations on molar and mass concentration. These topics are fundamental and basic concepts in chemistry.

In addition, several other studies have further established the phenomenon of low enrolment in chemistry in the Nigerian tertiary institutions (Aina & Akanbi, 2013; Osokoya, 2015 & Abanikannda, 2016). Glory (2020) equally alerted that chemistry was conspicuously missing from the list of 21 top sought after courses in Nigerian universities. The scenario obviously portends grave danger for future industrialization and science education in Nigeria and a great concern to science educators. On this note, researchers such as Samuel (2018) and Agu and Samuel (2018) observed that poor instructional strategies employed in the teaching of chemistry by teachers contribute to students' under-achievement. Nja, Cornelius-Ukpebi, Edoho and Neji (2020) equally noted consistent poor performance of secondary school students in Chemistry and attributed the cause to defective teaching pedagogy.

Ogbu (2011) revealed that most teachers continue to use ineffective and teacher centered method such as conventional method in teaching. Conventional method of teaching refers to teaching using chalk and board for teachers, pen and paper for students (Nnorom, 2015). This encourages rote memorization of scientific concepts and principles without teachers and learners having deep understanding of scientific phenomena, concepts and theories (Okoli & Egbunonu, 2012). Further, it is unfair to the large student population in the classroom to continue with pedagogy that will not contribute to the development of highly needed 21st century skills (Dole, Bloom & Kowalske, 2016) assuring employment in the global market. While this trend calls for serious attention of all stakeholders, more effective strategies which can enhance the study of science where the students will be active participants have been advocated (Ogunleye & Bamidele, 2013) and need to be explored. The effectiveness of teaching and learning process can be facilitated through appropriate strategies adopted in a learning environment (Adesoji, Omilani & Nyinebi, 2015). There is the need for more activity oriented and students centered methods that can develop in the students' science process skills, which include problem-based learning strategy. Problem-based learning is active learning technique that helps students to develop higher-level cognitive abilities, such as critical thinking and problem solving, through collaborative group work and reflection on their own learning (Wenger, 2014). It positions students as active knowledge seekers and co-creators who organize new relevant experiences and integrate same into prior knowledge (Yew & Goh, 2016). To Simunza, Banda and Hayumbu (2020), problem-based learning is an approach where learners are in the focus of the learning process. In this approach, learners work in groups to cooperate on the ways to solve a given problem. The aim of choosing PBL as a learning approach is to create a learning environment where both genders can actively participate in the learning process and contribute meaningfully to the learning situation (Iji, Emaikwu, & Utubaku, 2015). Hallinger and Bridges (2016, 2) proposed "PBL as an alternative teaching–learning approach that sought to create an active, problem-focused, practice-oriented environment for management education**".** This is because PBL as a learning approach helps to balance the gender gap that exists in the mode of learning of both male and female students. From all indications, PBL strategy is an effective way to teach chemistry in order to improve learners' critical thinking, problem solving skills, gender equity, interest and academic achievement.

Achievement is a measure of how successfully a student has accomplished a given academic task after teaching. Its purpose is to find out the stand of a student at a given moment (Akani, 2017). It is useful in testing the retention of information and skill. It is also a determinant of the efficacy and efficiency of a given instruction (Kabutu, Oloyede & Bandele, 2015). It has been shown by Okoli (2012), that students' achievement in science subjects is gender dependent. Nduji and Madu (2020) see gender is a social or cultural construct, attribute and roles being given by the society and it varies from place to place or culture to culture. Some studies show superiority of male students above those of their female counterparts in chemistry; while others show female superiority over those of their male counterparts especially when speech and memory cues are incorporated into learning experiences given that the females have more advanced verbal activities (Etiubon & Ugwu,2018).

Students' own interest is also another factor that affects their achievement in their study of chemistry. Ojekwu and Ogunleye (2020) see students' interest as critical in the teaching-learning process. There is a growing body of evidence that students' interests are enhanced when they actively participate in activities regarding lesson objectives and lesson outcomes (Wiseman & Hunt, 2013). It is in view of these that this study became a necessity.

Statement of the Problem

Since chemistry is an activity-oriented subject, its teaching and learning is supposed to be result-oriented and learner-centered. This can only be achieved when teachers are favourably disposed using learner-centered methods which are activity-based for maximum self development and fulfilment of the learners. Unfortunately, the use of inappropriate strategies in teaching chemistry promotes concept difficult and poor academic achievement which constitutes a problem. This ugly situation has necessitated the need and use of strategy in which the students/learners acquire problem solving skills. Therefore, the study sought to determine the effect of problem-based learning strategy on secondary school students' achievement and interest in chemical equilibrium in Ankpa local government area of Kogi state.

Research Questions

The following research questions were posed to guide the study:

i). What are the mean achievement scores of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy?

ii). What are the mean interest scores of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy?

iii). What are the mean achievement scores of male and female students taught Chemical Equilibrium with problem-based learning strategy?

iv). What are the mean interest scores of male and female students taught Chemical Equilibrium with problem-based learning strategy?

Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 significance level:

HO_1: There is no statistically significant difference in the mean achievement scores of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy.

Ho_2: There is no statistically significant difference in the mean interest score of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy.

HO_3: There is no statistically significant difference in the mean achievement scores of male and female students taught Chemical Equilibrium with problem-based learning strategy.

HO_4: There is no statistically significant difference in the interest scores of male and female students taught Chemical Equilibrium.

Research Methodology

The research design adopted pre-test, post-test quasi-experimental design non-equivalent control group. The target population of the study was made up of 2, 996 (comprised of 1,210 males and 1,786 females) Senior Secondary Schools II chemistry students in all 57 approved secondary schools in Ankpa Local Government Area of Kogi state. Purposive sampling technique was used to select two equivalent co-educational secondary schools that are distantly located from one another within Ankpa LGA which are considered intact class setting. The sample of the study comprised of 62 SSS II students consisting 22 females and 40 males. The two schools were randomly assigned experimental group and control group. Students in the experimental group were taught chemical equilibrium using problem-based learning strategy and those in control group were taught using conventional lecture method.

Two instruments namely: Chemical Equilibrium Achievement Test (CEAT) and Chemical Equilibrium Interest Scale (CEIS) were developed by the researcher and used for data collection. The instruments were subjected to content and face validity by three experts drawn from department of curriculum studies, department of chemistry and measurement and evaluation, Kogi State College of Education Ankpa. For reliability, The CEAT and CEIS were pilot tested using an intact SS II class of 50 students of senior secondary school in Anyingba (Dekina LGA of Kogi

state). The school has similar features to sample schools.

Experimental Procedures

The researchers used the permanent chemistry teachers in the sampled secondary schools as research assistants to teach Chemical equilibrium in their respective intact classes. One week training programme was organized for the permanent chemistry teacher in the experimental group on how to implement respective researchers-made instructional procedures and lesson plans for problem-based learning strategy. Before the commencement of the treatment, the CEAT and CEIS were administered to the students as a pre-test in the first week of the research to both the experimental and control groups. At the end of the fifth week of the treatment, the CEAT and CEIS were reshuffled and administered as post-test to the students to determine the effect of the treatment. For data analysis, The research questions were answered using descriptive statistics such as mean and standard deviations while all the hypotheses were tested at 0.05 level of significance using Analysis of Co-variance (ANCOVA) with the pre-test scores as a covariate.

Results and Discussion

Research Question One: What are the mean achievement scores of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy?

Table 1: Mean and Standard Deviation of Students Taught Chemical Equilibrium using problem-based learning strategy and those taught with conventional lecture strategy?

Treatment Groups	N	Pre-test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Problem-based learning	35	11.51	3.2663	57.43	10.0126	45.92
Conventional lecture	27	12.04	3.0317	38.04	7.8764	26.00

Source: Field Study
Key: N=Number of Student and SD= Standard Deviation.

Table 2: Result of ANCOVA on Students' Achievement Mean Score of Students taught Chemical Equilibrium with Problem-based learning strategy and those taught using conventional Lecture strategy for testing Hypothesis 1.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7843.261a	2	3921.631	79.518	.000	.729
Intercept	2669.773	1	2669.773	54.135	.000	.478
Pre-Test	2111.812	1	2111.812	42.821	.000	.421
Group	6281.498	1	6281.498	127.369	.000	.683
Error	2909.722	59	49.317			
Total	159517.000	62				
Corrected Total	10752.984	61				

a. R Squared = .729 (Adjusted R Squared = .720). P< 0.05

Data in Table 1 show that the pre-test and post-test mean scores of students taught chemical equilibrium using problem-based learning strategy are 11.51 and 57.43 while the pre-test and post-test mean scores of students taught with conventional lecture strategy are 12.04 and 38.04 respectively. The mean gain of problem-based learning strategy group of 45.92 is higher than that of conventional lecture strategy group (26.00). This shows that students taught chemical equilibrium using problem-based learning strategy perform better than the students taught with conventional lecture strategy.

Hypothesis One: There is no statistically significant difference in the mean achievement scores of students taught Chemical Equilibrium with problem-based learning strategy and those taught using Conventional lecture strategy.

The result in the Table 2 show that there is significant difference in the mean achievement scores of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy. This is because the p-value (.000) is less than the level of significant (0.05). Based on the above, the null hypothesis is rejected, implying that problem-based learning strategy is more effective than the conventional lecture strategy.

Research Question Two: What are the mean interest scores of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional learning strategy?

Table 3: Mean and Standard Deviation of Interest of Students Taught Chemical Equilibrium using problem-based learning strategy and those taught with conventional lecture strategy?

Treatment Groups	N	Pre-Interest		Post-Interest		Mean Gain
		Mean	SD	Mean	SD	
Problem-based learning	35	20.06	7.0708	62.69	9.6399	42.63
Conventional lecture	27	19.89	6.7729	39.74	6.9702	19.85

Source: Field Study

Table 4: Result of ANCOVA on Students' Mean Interest Score of Students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy for testing Hypothesis 2.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8059.157a	2	4029.579	54.181	.000	.647
Intercept	15575.166	1	15575.166	209.419	.000	.780
Pre-interest	34.708	1	34.708	.467	.497	.008
Group	8010.368	1	8010.368	107.705	.000	.646
Error	4388.020	59	74.373			
Total	184597.000	62				
Corrected Total	12447.177	61				

a. R Squared = .647 (Adjusted R Squared = .636). P< 0.05.

Data in Table 3 show that the pre-test and post-test mean interest scores of students taught problem-based learning strategy are 20.06 and 62.69 while the pre-test and post-test mean interest scores of students taught conventional lecture strategy are 19.89 and 39.74 respectively. The mean interest gain of students taught problem-based learning strategy of 42.63 is higher than that of students taught students taught conventional lecture strategy which is 19.85. This implies that students taught chemical equilibrium using problem-based learning strategy develop more interest than the students taught with conventional lecture strategy.

Hypothesis Two: There is no statistically significant difference in the mean interest score of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy.

The result in the Table 4 show that there is no significant difference in the mean interest score of students taught Chemical Equilibrium with problem-based learning strategy and those taught using conventional lecture strategy.

This is because the p-value (.000) is less than the level of significant (0.05). Based on the above, the null hypothesis is rejected, implying that problem-based learning strategy enhances students' interest than the conventional lecture strategy.

Research Question Three; What are the mean achievement scores of male and female students taught Chemical Equilibrium with problem-based learning strategy?

Table 5: Mean and Standard Deviation of Achievement Score of Male and Female Students taught Chemical Equilibrium with Problem-based learning strategy

Gender	N	Pre-test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Male	20	11.70	3.4959	58.05	8.7146	46.35
Female	15	11.27	3.0347	56.60	11.7947	45.40

Table 6: Result of ANCOVA on Achievement Mean Score of Male and Female students taught Chemical Equilibrium with problem-based learning strategy for testing Hypothesis 3

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	40.401a	2	20.201	.192	.826	.012
Intercept	7523.401	1	7523.401	71.478	.000	.691
Pre-Test	22.380	1	22.380	.213	.648	.007
Gender	15.371	1	15.371	.146	.705	.005
Error	3368.170	32	105.255			
Total	118840.000	35				
Corrected Total	3408.571	34				

a. R Squared = .012 (Adjusted R Squared = -.050).P> 0.05

Data in Table 2 show that the pre-test and post-test mean scores of male students taught chemical equilibrium using problem-based learning strategy are 11.70 and 58.05 while the pre-test and post-test mean scores of female students are 11.27 and 56.60 respectively. The mean gain of male students of 46.35 is almost at par with mean gain of their female counterpart which is 45.40. This implies that the mean achievement scores of male and female students perform almost equally when exposed to problem-based learning strategy.

Hypothesis Three: There is no statistically significant difference in the mean achievement scores of male and female students taught Chemical Equilibrium with problem-based learning strategy.

The result in the Table 6 show that there is no statistically significant difference in the mean achievement scores of male and female students taught Chemical Equilibrium with problem-based learning strategy. This is because the p-value (0.705) is greater than the level of significant (0.05). Based on the above, the null hypothesis is accepted, implying that, the use of problem-based learning strategy enhances equal achievement in male female students learning of chemical equilibrium.

Research Question Four: What are the mean interest scores of male and female students taught Chemical Equilibrium with problem-based learning strategy?

Table 7: Mean and Standard Deviation of Interest Score of Male and Female Students taught Chemical Equilibrium with Problem-based learning strategy

Gender	N	Pre-Interest		Post-Interest		Mean Gain
		Mean	SD	Mean	SD	44.40
Male	20	20.80	7.7433	65.20	10.3089	40.26
Female	15	19.07	6.1814	59.33	7.7705	

Table 8: Result of ANCOVA on Interest Mean Score of Male and Female Students taught Chemical Equilibrium with problem-based learning strategy for testing Hypothesis 4.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	319.998a	2	159.999	1.803	.181	.101
Intercept	15708.257	1	15708.257	177.023	.000	.847
Pre-Interest	24.988	1	24.988	.282	.599	.009
Gender	311.894	1	311.894	3.515	.070	.099
Error	2839.545	32	88.736			
Total	140692.000	35				
Corrected Total	3159.543	34				

a. R Squared = .101 (Adjusted R Squared = .045). P>0.05

Data in Table 2 show that the pre-test and post-test mean interest scores of male students taught chemical equilibrium using problem-based learning strategy are 20.80 and 65.20 while the pre-test and post-test mean scores of female students are 19.07 and 59.33 respectively. The mean interest gain of male students of 44.40 is almost at par with mean gain of their female counterpart which is 45.40 with a difference of 4.14 interest mean gain. This implies that, the use of problem-based learning strategy enhances interest of both male and female almost equally.

Hypothesis Four: There is no statistically significant difference in the interest scores of male and female students taught Chemical Equilibrium.

The result in the Table 8 show that, there is no there is no statistically significant difference in the interest scores of male and female students taught Chemical Equilibrium using problem-based learning strategy. This is because the p-value (0.070) is greater than the level of significant (0.05). Based on the above, the null hypothesis is accepted, implying that, the use of problem-based learning strategy enhances male and female student's interest equally in learning of chemical equilibrium.

Discussion of Results

Result of data analysis (See Tables 1 and 2) have shown that students taught chemical equilibrium with problem-based learning strategy performed significantly better on the achievement test than their counterparts who were taught using the conventional lecture strategy of instruction. This finding confirms the findings of Ntibi and Neji (2018); Nnorom (2019) and Simunza, Banda and Hayumbu (2020) who found out that students taught chemistry with problem based learning perform better than those students taught with conventional lecture strategy in sciences.

In addition, it was discovered that the use problem-based learning strategy enhanced students' interest in learning chemical equilibrium (See Tables 3 and 4). This finding affirmed the findings of Omaga, Iji and Adeniran (2017); Jimoh and Fatokun (2020) assertion that problem-based learning improved students' motivation in learning. Furthermore, as indicated in tables 4 and 6, the mean achievement scores of male students taught chemical equilibrium using problem-based learning strategy was found to be almost at par with that of their female counterparts. This indicates that gender is not a strong determinant of students' academic achievement. This finding agrees with the

findings of Ajai and Imoko (2015) and Anyafulude (2014) who showed that PBL is a non-gender discriminatory instructional strategy in terms of enhancing students' interest and achievement in their subjects of study.

Finally, it was equally noted that there is no statistically significant difference in the interest gain of male and female students exposed to problem-based learning strategy(see Tables 7and 8). This finding is in consonant with Fatokun (2012) who reported that there is a significant difference in the interest gain of male and female students in mole concept of chemistry.

Conclusion

From the results obtained, it was discovered that problem-based learning strategy is a very effective instructional strategy on academic achievement and interest of students in Chemical equilibrium compare to the conventional lecture strategy. Also, problem-based learning strategy is non-gender and non-interest discriminatory instructional strategy.

Recommendations

i). Curriculum planners should incorporate and emphasize the use of problem-based learning strategy in the teaching of chemistry.

ii). Science teachers should be encouraged to use problem-based instructional strategy in teaching senior secondary school chemistry.

iii). Federal and State Ministries of Education and relevant professional associations should organize workshops for teachers to update their teaching methodology on the implementation of problems of learning strategy for instruction.

iv). Gender-based innovative techniques should be considered when selecting instructional strategy for teaching and learning of chemistry and science in general.

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