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PROBLEM-BASED VERSUS LECTURE-BASED LEARNING ENVIRONMENTS: EFFECT ON STUDENTS' ATTITUDE AND PERFORMANCE IN CHEMISTRY AT SECONDARY SCHOOL LEVEL

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ABSTRACT
Teaching and learning strategies which has been a serious issue in chemistry education have a strong impact on the attitudes and performance of the students and their acquisition of skills. Thus, the main purpose of this study was to provide the evidence of the effectiveness of problem-based learning (PBL) and lecture-based learning (LBL) environments in relation to students' attitudes and academic performance. The study adopted a quasi-experimental design with a population that comprised all Secondary School Two (SS II) Chemistry students in Jalingo Education Zone, Taraba State; from were a sample of 95 students from two intact classes of two schools was purposively sampled. Two instruments, Chemistry attitude questionnaire (CAQ) and Chemistry performance test (CPT) were used for data collection. Data collected was analyzed using mean and standard deviation to answer the research questions, while the hypotheses were tested using ANOVA at 0.05 level of significance. Findings revealed that there is a significant difference in attitude of students taught Chemistry using PBL and LBL; in favour of PBL. Findings also revealed that there is a significant difference in performance in Chemistry of students taught using PBL and LBL; in favour of PBL. It was concluded that PBL is viable and has potential to enhance secondary school students' attitude and performance in Chemistry more than the LBL that is prominently used in the teaching-learning process. It was recommended amongst others that Chemistry teachers should be trained to create a friendly PBL environment in the teaching of chemistry at the secondary school level since it enhances students' attitudes and performance.

Keywords: Problem-based learning, Lecture-based learning, Attitude, Performance, Gender, Chemistry.

Introduction

Learning is a purposeful, conscious and complex process which involves a complex interactive system including environmental, social, motivational, emotional and cognitive factors. According to McKnight, O'Malley, Ruzic, Horsley, Franey, Bassett, (2016), there is classroom instruction methods evolution which has been exhilarated by the progress of several learning ideologies and techniques of instruction, including active learning, student-centred learning, collaborative learning, experiential learning, and problem-based learning. And, as observed by Zaidi, Hammad, Awad, Qasem and Al-Mahdi (2017), these strategies are sharing essential primary features and can be considered as

complementary elements of a wider method of classroom instructions. Various teaching-learning strategies have been developed to accelerate learning process of students. Learning strategies evolve from the learning theories defining the role of teacher, students and the contents; but most behavioural practices in schools makes students passive and the classroom environment dominated by the teacher. Hence, for effective teaching to take place, the teacher must stimulate, encourage and maintain active participation of the students through the selection of appropriate teaching methods. This would require a balance between what is taught and how it is taught. Therefore, the successful teaching of Chemistry does not depend only on the teacher's mastery of the subject matter but also the instructional method employed. This implies that what students learn is greatly influenced by how they are taught.

Teaching Chemistry can only be result-oriented when students are willing and the teachers are favourably disposed to using appropriate methods and resources in teaching the students. With the current increase in scientific knowledge the world over, much demand is placed, and emphasis is laid on the teacher, the learner, the curriculum and the environment in the whole process of teaching and learning of science generally and chemistry in particular. Despite the importance of Chemistry to mankind most students emerge from the introductory courses with very limited understanding of the subject (Kamisah & Nur, 2013; Woldeamanuel, Atagana & Engida, 2014), and the performance of the subject remains low; which may have resulted from the lack of understanding and difficulties of students in some chemistry concepts as reported by the Chief Examiner, (WAEC, 2020). Chemistry had been regarded by most researchers (Jack, Danjuma & Adul-Kadir, 2017; Kamisah & Nur, 2013; Woldeamanuel et al. 2014) as a difficult subject for students due to the abstract nature of many chemical concepts, the difficulty language of chemistry, lack of teaching aids, and poor teaching styles; hence students developing poor understanding and misunderstanding of chemistry concepts. Also, from investigations of these educators (Gongden, 2016; Jack et al. 2017), stipulated that students' poor problem solving ability, conceptual or learning difficulties and misconceptions in Chemistry is a likelihood of a deficiency in instructional strategies used in the chemistry classrooms. Babale, Lawal, and Ibrahim, 2018) also noted poor methods of instruction (mostly the traditional teaching methods) among the factors that have been identified with poor performance and attitude in Chemistry. Amongst the traditional learning environments is the lecture-based learning (LBL).

LBL is frequently a one – way process dominated by the teacher and unaccompanied by discussion, questioning or immediate practice; and concentrates on information rather than learners (Al-Rawi, 2013). In the LBL the teacher tell the students what to do instead of activating them to discover for themselves (Miles, 2015). The LBL

method according to Zaidi et al (2017) is based on memorizing which means the encyclopedic knowledge is much valued rather than the acquisition of skills. In the LBL the learners are passive recipients; which might lead to discouraging students from becoming active in communicating their needs to their instructor. But when it comes to the preparations for the test and answering the questions as observed by Zaidi et al (2017,) the LBL is more convenient for students who usually find it useful to have lecture notes that will help them in reviewing the topics prior to conducting the tests the thing that helps in getting good grades. Evidence is mounting that these traditional methods could be less effective in helping our students in developing problem solving skills and understanding/mastery basic science concepts taught. This implies that a problem could be solved once the learner is able to identify the differences between what he already learns and the new knowledge. This could be performed through the use of problem-based learning.

Problem-based learning as described by Klegeris and Hurren, (2011) is a technique where problem drives the learning in a learning environment in small groups, supervised by tutors. Hence, in PBL environment students' work in small collaborative groups on open ended problems which are realistic and is centred on the student. It also empowers learners in integrating theory and practice, in conducting research; developing a viable solution by applying skills and knowledge and where teacher is just a facilitator who facilitates the learner in constructing knowledge.

Problem-based learning (PBL) is a term used for a range of pedagogical approaches that encourage students to learn through the structured exploration of a research problem. It is an active learning strategy which enables the student to become aware of what is learnt and determines his/her problem solving ability. PBL strategy helps to determine learning needs; and as opined by Ongowo and Indoshi, (2013), it is able to make knowledge operative and to perform group works "in the face of real-life problems". PBL strategy requires students to become responsible for their own learning with the teacher playing the role of a facilitator. The strategy portrays teacher's intervention in the learning process which diminishes as students progressively take on responsibility for their own learning processes through critical thinking and problem solving skills.

Problem solving skills refer to the ability of an individual to find meaningful solutions to solve problems using effective and timely strategies (Karabacak, Nalbant, & Topçuoglu, 2015). Problem solving is a systematic approach in conceptualizing and understanding a given problem, designing strategies to solve the problem, and evaluating the strategies implemented. In science education, "the term 'problem solving" refers to mathematical tasks that have the potential to provide intellectual challenges for enhancing students' scientific understanding and

development. Such tasks can promote students' conceptual understanding, foster their ability to reason and communicate mathematically, and capture their interests and curiosity. Problem solving has become an important component of science education; hence science teachers are considered shifting of emphasis from teaching problem solving to teaching through problem solving in a PBL environments.

Problem-based learning is a teaching method in which complex real-world problems are used as the vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts. In addition to course content, PBL can help promote the development of critical thinking skills, problem-solving abilities, and communication skills. It can also help provide opportunities for working in groups, finding and evaluating research materials, and life-long learning (Duch, Groh, & Allen, 2001). The core idea of PBL is that real-world problems capture students' interest and provoke serious thinking as the students acquire and apply new knowledge in a problem-solving context. The teacher plays the role of facilitator, working with students to frame worthwhile questions, structuring meaningful tasks, coaching both knowledge development and social skills, and carefully assessing what students have learned from the experience.

The PBL environment is characteristically carried out in small, facilitated groups and takes advantage of the social aspect of learning through discussion, problem solving, and study with peers. The facilitator guides students in the learning process, pushing students to think deeply, and models the kinds of questions that students need to be asking themselves, thus forming a cognitive apprenticeship. The class activities are also constructed around a problem; and the application is not teacher activity-centred but student activity-centred. The teacher's integration of PBL into the subject teaching makes students empowered to take a responsible role in their learning. The instructor applying this strategy to teach is not the authoritative source of information and knowledge. Students have to take the initiative to inquire and learn; and the instructor only guide, probe and support students' initiatives. What students learn during their self-directed learning is applied back to the problem with re-analysis and resolution.

Problems are used as a stimulus for students to start the learning process. The students' reason through the problem and find out what they have already known and what they should know in order to solve the problem. It is through this active and reflective thinking process that students become responsible for their own learning. Through the application of their knowledge to the problem, the students test and integrate what they are learning. In general, PBL aims to motivate students to participate in the learning process and to help foster problem solving skills. In using the PBL, the teacher teaches by integrating theory and practical activities.

Acquiring skills and understanding of concepts through the process of individual learning can be tedious, boring, and overwhelming. When teachers allow learners to work together, the learning process becomes interesting and fun despite the nature of the subject (Laal & Ghodsi, 2012). Through the use of problem-based learning or problem solving approach (as applicable in some of the studies) by previous researchers (Abdullah,Tarmizi, & Abu, 2010; Achuonye, 2010; Adegoke, 2017; Aidoo, Boateng, Kissi, Philip & Ofori, 2016; Akubuilo, 2015; Argaw, Haile, Ayalew, & Kuma, 2017; Awodun, 2015; Boris, 2020; Delmang & Gongden, 2016; Fatade, Mogari, & Arigbabu, 2013; Itodo, 2019; Klegeris & Hurren, 2011; Mambwe & Overson, 2020; Nbina & Joseph, 2011; Neşe & Neşe, 2014; Ntibi & Neji, 2018; Obochi, 2021; Ogweno, Kathuri & Nkurumwa, 2021; Omaga, Iji, & Adeniran, 2017; Osuafor & Orji, 2017; Semeneh, 2020) in various field of science, observed that learners could achieve higher, and develop more positive attitude/interest towards science subjects; but there exists a gap in the present study area (Jalingo, Taraba State).

The PBL environment can help facilitate learner's performance in Chemistry and improve their interest in the subject. Interest is a state of curiosity or concern about something or the attention given to something; hence is an important factor that supports learning, individual development and performance. According to Godpower-Echie and Sopuruchi (2017) if a student shows a higher interest in a course, this will help him to put in more time, effort and energy in learning which will in turn lead to higher or better performance. And, the issue of gender has also played a major role in the attitudes of students and their performances in core science subjects.

The fall in standard of performance at secondary level chemistry may be incontrovertibly attributable to instructional methods adopted by teachers in schools. Thus, there may be need for Chemistry teachers to adopt appropriate instructional methods that may stimulate students' attitude and help enhance students' performance in the subject. It is on this premise that this study sought to examine the effects of problem-based learning and those taught using lecture-based learning environments on students' attitude and performance in Chemistry. The problem of this study therefore is, "will the application of problem-based learning be effective in enhancing students' attitude and performance in Chemistry? The purpose of this study was to investigate the effects of problem-based learning versus lecture-based learning environments on students' attitude and performance in Chemistry.

To guide the study, the following research questions were posed thus:

i. What is the difference in attitude of students taught Chemistry using problem-based and lecture-based learning environments?
ii. What is the influence of gender on students' mean attitude scores in Chemistry

using problem-based and lecture-based learning?

iii. What is the difference in performance of students taught Chemistry using problem-based and lecture-based learning environments?

iv. What is the influence of gender on students' mean performance scores in Chemistry using problem-based and lecture-based learning?

To also guide the study the following null hypotheses were tested at 0.05 level of significance thus:

$H0_1$: There is no significant difference in attitude of students taught Chemistry using problem-based and lecture-based learning environments.

$H0_2$: There is no significant difference in attitude of male and female students taught Chemistry using problem-based learning.

$H0_3$: There is no significant difference in performance of students taught Chemistry using problem-based and lecture-based learning environments.

$H0_4$: There is no significant difference in performance of male and female students taught Chemistry using problem-based learning.

Research Method

This study adopted quasi-experimental design using pre-test and post-test with control and experimental groups. This design was considered fit because the study estimated the causal effects of problem-based learning on attitude and performance in Chemistry and all conditions for a true experimental design was not possible in the schools.

The population of the study was all SS II students in Secondary Schools in Jalingo, Taraba State in 2020/2021 academic session. A sample of 95 (50 males & 45 females) SS II students made up of two intact classes (assigned as experimental & control groups) of Secondary Schools Jalingo Local Government Area, was selected using purposive sampling due to the nature of the study. The experimental is has an intact class of 45 students (24 males & 21 females); while the control group had 50 students (27 males & 23 females).

Two instruments developed by the researcher were used in data collection for the study; a questionnaire and a performance test. The questionnaire is tagged "Chemistry Attitude Questionnaire (CAQ)". This questionnaire was developed by the researcher and to measure students' attitude towards Chemistry to be used as pre-test and post-test for both experimental and control groups. The pre-test was used to measure students' attitude towards Chemistry before the exposure of the treatment to the experimental groups. On the other hand, the post-test was used to measure students' attitude towards Chemistry after the treatment. The items of the pre-test CAQ were re-arranged to form the post-test CAQ items. The respondents were required to tick the chosen

response representing their viewpoint from several answer categories. This means the structure of the questions was close ended questions on a four point scale of SA=Strongly Agreed (4 points), A=Agreed (3 points), D= Disagreed (2 points), and SD= Disagreed (1 point). The advantage of close ended questions is that they are manageable since the respondents are restricted to a finite set of responses.

The other instrument for data collection was a performance test tagged Chemistry Performance Test (CPT), the performance test was administered to both control and experimental groups to measure their performance in Chemistry. CPT is a 40 item 4-options multiple choice questions; where the right option is 1 and the wrong option is 0. The CPT pre-test assessment test was administered to both groups to measure the students' performance in Chemistry before the exposure of the treatment. The questions were generated based on selected Chemistry content of second term SS2 topics: oxidation and reduction reactions, mass-volume relationship and electrolysis used for the study. This is to ensure equivalence of control and experimental groups. The post-test was used to measure the students' performance in Chemistry for both experimental and control groups after the treatment.

The two instruments for data collection (CAQ & CPT) were taken to three experts for face and content validation. To ensure both face and content validity; the experts checked for ambiguity of items in relation to the research variables, appropriateness of the items, construction and structure of the items, good reflection of the objectives, clarity of the items and options, and relevance to the issue under investigation. The comments and suggestions to be made by these experts were used to review the instruments.

The instruments for data collection were used for pilot testing to ascertain the reliability of the instrument for the study in order to ensure consistency in the responses. A total of 30 students were used to trial-test both CAQ and CPT. In determining the reliability of the CAQ the data obtained from pilot testing were analyzed using Cronbach Alpha's method to ensure the level of internal consistency in the responses. The Cronbach's alpha statistical tool was used in determining the reliability coefficient of 0.81 for the CAQ. Responses obtained from CPT were used to test the reliability of the instrument using Split-half method of testing reliability which was found to be 0.87. The value of the coefficient obtained is high which indicates that the instrument is reliable and suitable for the study. The school that was involved for the pilot test was outside the study area to avoid experimental bias.

The problem-based learning adapted for this study is by Duch, Groh, and Allen, (2001) with the following principles:

i. The problem must motivate students to seek out a deeper understanding of concepts;
ii. The problem should require students to make reasoned decisions and defend them;

iii. The problem should incorporate the content objectives in such a way as to connect it to previous courses/knowledge;
iv. If used for a group project, the problem needs a level of complexity to ensure that the students must work together to solve it; and
v. If used for a multi-stage project, the initial steps of the problem should be open-ended and engaging to draw students into the problem.

The problems emanated from a variety of sources: newspapers, magazines, journals, books, textbooks, and television/movies; where some of the sources were modified before use. The following guidelines from 'The power of problem-based learning' (Duch et al, 2001) are written for creating problems for a class centred on PBL; however, the general ideas as applied in this study are:

i. Choose a central idea, concept, or principle that is always taught in a given course, and then think of a typical end-of-chapter problem, assignment, or homework that is usually assigned to students to help them learn that concept. Also, list the learning objectives that students should meet when they work through the problem;
ii. Think of a real-world context for the concept under consideration. Develop a discussion aspect to an end-of-chapter problem, or research an actual case that can be adapted, adding some motivation for students to solve the problem. More complex problems will challenge students to go beyond the classroom environments to solve it through critical thinking, creative skills;
iii. The problem were introduced in stages so that students were able to identify learning issues that will lead them to research the targeted concepts. The following are some questions that may help guide this process;
a. What will the first page (or stage) look like? What open-ended questions can be asked? What learning issues was identified?
b. How will the problem be structured?
c. How long will the problem be? How many class periods will it take to complete?
d. Will students be given information in subsequent pages (or stages) as they work through the problem?
e. What resources will the students need?
f. What end product will the students produce at the completion of the problem?
iv. Write a teacher's guide detailing the instructional plans on using the problem in the lesson. If the lesson is taught in a medium/large-size class, a combination of mini-lectures, whole-class discussions, and small group work with regular reporting may be necessary. The teacher's guide can indicate options for cycling through the pages of the problem using various modes of learning; and
v. The final step is to identify key resources for students. Students need to learn to identify and utilize learning resources on their own,

but it can be helpful if the teacher indicates a few good sources to get them started. Many students will want to limit their research to the Internet, so it is important to guide them toward the library as well.

While, in the lecture-based learning (LBL) environment for the control group, a traditional classroom teaching (teacher-centred & content-oriented) where the teacher does more of the verbal explanations and demonstrations in combination of chalkboard or dry-erase whiteboard to facilitate learning the interaction between the teacher and students. The learning environment was also a traditional lecture-based and majorly designed to promote learning through practice questions, exercise drills and teacher demonstrations; where learners are passive recipients. Hence, the students mainly takes down notes and responds to exercise questions since the mode of instruction or learning contents was through drill and practice. And, the LBL environment typically permits less classroom interaction between the teacher and the students, and even the students themselves; since it is teacher-dominated.

All the topics selected from Chemistry content of second term SS2: oxidation and reduction reactions, mass-volume relationship and electrolysis used for the study where adequately taught using the lesson notes prepared for the control and experimental groups taught with LBL and PBL environments respectively. The administration of the instrument and collection phase lasted for six weeks for both experimental and control groups who were taught with problem-based learning and lecture-based learning respectively. The study was carried out in two stages, having pre/post testing (two-time point intervention) of the students.The pre-test was given to both groups to ascertain their initial equivalence before exposure to the treatment. After the treatment, post-test was administered to both the control and experimental group.

Data collected was analyzed using Mean and Standard deviation. While all the hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA); where the pre-test scores are the covariates to ascertain the entry equivalence. The use of ANCOVA analysis was to "statistically control" for influence of confounding variables. A p-value of less than 0.05 ($p<0.05$) was considered to be statistically significant.

Presentation of Results

Answering Research Question One: What is the difference in attitude of students taught using problem-based and lecture-based learning environments?

Table 1. Mean and Standard Deviation of Attitude Scores of Students taught Chemistry using Problem-based and Lecture-based learning

		Pre-test		Post-test		
Method	N	Mean	SD	Mean	SD	Mean gain

Problem-based learning (PBL)	45	2.65	.55	3.61	.38	.96
Lecture-based learning (LBL)	50	2.70	.71	3.07	.48	.37
Mean difference		0.05		0.54		

Table 1 shows that the students that were taught Chemistry using PBL had post mean attitude score of 3.61 with a standard deviation of 0.38 while those that were taught using LBL had post mean attitude score of 3.07 with a standard deviation of 0.48. Mean attitude gain scores of 0.96 and 0.37 for the two groups respectively imply that the students that were exposed to PBL had higher attitude scores than their counterparts that used LBL, which showed that PBL is more attitude-friendly. The difference indicates that PBL has more positive effect on students' attitude towards Chemistry.

Answering Research Question Two: What is the influence of gender on students' mean attitude scores in Chemistry using problem-based and lecture-based learning?

Table 2. Mean and Standard Deviation of Attitude Scores of Students taught Chemistry based on gender

			Pre-test		Post-test		
Method	Gender	N	Mean	SD	Mean	SD	Mean gain
Problem-based learning (PBL)	Male	24	2.65	0.55	3.64	.36	0.99
	Female	21	2.60	0.51	3.57	.40	0.97
Lecture-based learning (LBL)	Male	27	2.64	0.68	3.03	.45	0.39
	Female	23	2.76	0.74	3.14	.51	0.35

Table 2 reveals the attitude mean scores of male and female students taught Chemistry using PBL and LBL. The analysis shows that male and female students had post attitude mean scores of 3.64 and 3.57 for PBL with mean gains of 0.99 and 0.97 respectively; while for LBL the male and female students had mean gains of 0.39 and 0.35 respectively. The difference in mean attitude gain scores of male and female students between the two groups indicated that the experimental group taught with PBL had higher attitude scores than the control group taught with LBL; though within a group the difference between male and female performance is quite negligible.

Answering Research Question Three: What is the difference in mean performance scores of students taught

Chemistry using problem-based learning and lecture-based learning?

Table 3. Mean and Standard Deviation of Performance in Chemistry of Experimental and Control Groups after Treatment

		Pre-test		Post-test		
Method	N	Mean	SD	Mean	SD	Mean gain
Problem-based learning (PBL)	45	22.66	5.55	33.96	7.22	11.30
Lecture-based learning (LBL)	50	22.69	5.57	28.27	6.63	5.58
Mean difference		0.03		5.69		

Table 3 shows that the students that were taught Chemistry using PBL had post mean performance score of 33.96 with a standard deviation of 7.02 while those that were taught using LBL had post mean performance score of 28.27 with a standard deviation of 0.85. Table 3 also showed the mean performance gain scores of 11.30 and 5.58 for the two groups respectively. This imply that the students that were exposed to PBL had higher performance scores than their counterparts taught with LBL; implying that the strategy enhances academic performance positively. The difference indicates that PBL has positive effect on students' performance in Chemistry.

Answering Research Question Four: What is the influence of gender on students' mean performance scores in Chemistry using problem-based and lecture-based learning?

Table 4. Mean and Standard Deviation of Performance Scores of Students taught Chemistry based on gender

		Pre-test			Post-test		
Method	Gender	N	Mean	SD	Mean	SD	Mean gain
Problem-based learning(PBL)	Male	24	22.63	5.50	33.96	7.40	11.33
	Female	21	22.69	5.55	33.99	7.36	11.30
Lecture-based learning (LBL)	Male	27	22.63	5.60	28.35	6.45	5.72
	Female	23	22.67	5.64	28.19	6.51	5.52

Table 4 reveals the mean performance scores of male and female students taught Chemistry using PBL and LBL. The analysis shows that male and female students had post performance mean scores of 33.96 and 33.99 for PBL with mean gains of 11.33 and 11.30 respectively; while for LBL the male and female students had mean gains of 5.72 and 5.52 respectively. The difference in mean performance gain scores of male and female students between the two groups indicated that the experimental group taught using PBL had higher performance scores than their control group counterparts taught using LBL. This implies that PBL is gender-friendly.

Testing Hypothesis One ($H0_1$): There is no significant difference in attitude of students taught using problem-based learning and those taught using lecture-based learning.

Table 5. Analysis of Covariance (ANCOVA) of Attitude of Experimental and Control Groups

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	.969[a]	4	.242	1.052	.300
Intercept	39.364	1	39.364	58.221	.000
Pre-Attitude	6.749	1	6.749	1.230	.270
Method	.527	1	.527	16.455	.000
Gender	.212	1	.212	.205	.652
Method* Gender	.214	1	.014	.008	.960
Error	16.258	90	5.485		
Total	932.000	95			
Corrected Total	15.956	94			

a. R Squared = .069 (Adjusted R Squared = .017)

Table 5 presents Analysis of Covariance conducted to test the difference in attitude of students taught using PBL and those taught using LBL showed F=16.455, P=.000 (at P<0.05, Significant). Result of the analysis shows that, there is a significant difference in attitude of students taught using PBL and those taught using LBL. This indicates that PBL is effective on students' attitude towards Chemistry among secondary school students. Therefore, the null hypothesis which states that there is no significant difference in attitude of students taught using problem-based learning and those taught using lecture-based method is rejected.

Testing Hypothesis Two ($H0_2$): There is no significant difference in attitude of male and female students taught using problem-based learning.

Table 5 also presents Analysis of Covariance conducted to test the difference in attitude of male and female students taught using PBL showed F=.205, P=.652 (at P> 0.05, Not significant). Result of the analysis shows that, there is a significant difference in attitude of male and female students taught using problem-based learning. This indicates that gender difference has no significant influence on the effect of problem-based learning on students' attitude towards Chemistry. Therefore, the null hypothesis which states that there is no significant difference in attitude of male and female students taught using problem-based learning is retained.

Testing Hypothesis Three ($H0_3$): There is no significant difference in performance in Chemistry of students taught using problem-based learning and those taught using lecture-based method.

Table 6. Analysis of Covariance (ANCOVA) of Students' performance in Chemistry on Experimental Group Based on Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1463.288[a]	4	3707.620	28.657	.000
Intercept	1426.550	1	1426.550	80.520	.000
Pretest	180.414	1	180.414	33.085	.029
Method	12161.616	1	12161.616	69.522	.000
Gender	136.250	1	136.250	.795	.370
Method* Gender	140.502	1	140.502	.802	.395
Error	11463.513	90	195.045		
Total	149010.000	95			
Corrected Total	21950.442	94			

a. R Squared = .566 (Adjusted R Squared = .550)

Table 6 presents Analysis of Covariance conducted to test the difference in performance in Chemistry of students taught using PBL and those taught using LBL. Result of the analysis shows that (F=69.522, P=.000; P<0.05, Significant), there is a significant difference in performance in Chemistry of students taught using PBL and those taught using LBL. This indicates that PBL is effective on students' performance in Chemistry among secondary school students. Therefore, the null hypothesis which states that there is no significant difference in performance in Chemistry of students taught using PBL and those taught using LBL is rejected.

Testing Hypothesis Four ($H0_4$): There is no significant difference in performance of male and female students taught Chemistry using problem-based learning.

Table 6 also presents Analysis of Covariance conducted to test the difference in performance in Chemistry

of male and female students taught using PBL and those taught using LBL. Result of the analysis shows that (F=0.795, P=.370; P>0.05= Not Significant), there is no significant difference in performance in Chemistry of male and female students taught using PBL and those taught using LBL; and there is no significant difference (F=0.802, P=.395; P>0.05, Not Significant) in performance in Chemistry of male and female students taught using PBL. This indicates that PBL is effective on students' performance in Chemistry among secondary school students. Therefore, the null hypothesis which states that there is no significant difference in performance in Chemistry of male and female students taught Chemistry using problem-based learning is no rejected. This shows that PBL is gender-friendly.

Discussion of Findings

In testing the hypothesis on effect of PBL and LBL environments on students' attitude towards Chemistry; the findings revealed that there is a significant difference in attitude of students taught using PBL and LBL; in favour of PBL. This finding is in agreement with Ntibi and Neji (2018) who revealed that the experimental groups taught with guided problem-solving approach had a higher mean score than the control group taught with lecture-based method in Physics and Chemistry. This finding also supports previous researchers (Knogler, 2014; Itodo, 2019; Neşe & Neşe, 2014; Omaga et al 2017; Semeneh, 2020) who revealed in their various studies that the use of PBL (or problem-solving as used by some educators) help improved students attitudes towards biology, Chemistry or physics respectively.This may have resulted from PBL environment that allowed learners to explore knowledge themselves through identifying the problems found in the cases or materials that was presented to them by their instructors; and students worked to bring solutions to these problems which helped in arousing their attitudes.

Investigating the gender difference on the effect of PBL on students' attitude towards Chemistry; the finding showed that there is no significant difference in attitude of male and female students taught using PBL. This finding is in line with Ajayi, Agamber and Angura (2017) who found that there is no significant difference in the mean interest scores between male and female students taught standard mixture separation techniques using ethnoChemistry approach in Ebonyi State, Nigeria. The finding also supports Omaga et al (2017) who found that male students had a slightly higher mean interest rate when they learnt electricity using PBL approach than their female counterparts but the difference was not statistically significant. The findings is also in line with Itodo (2019) who revealed that there was no significant difference in the mean interest scores of male and female students in Biology in the experimental group. On the contrary, Godpower-Echie and Sopuruchi (2017) found out that gender has a significant influence on the interest of Science students.

In assessing the effect of problem-based learning on sstudents' performance in Chemistry; the finding revealed that there is a significant difference in performance in Chemistry of students taught using PBL and those taught using LBL. This finding is in agreement with these previous researchers (Abdullah et al 2010; Achuonye, 2010; Adegoke, 2017; Aidoo et al 2016; Akubuilo, 2015; Argaw et al 2017; Awodun, 2015; Boris, 2020; Delmang & Gongden, 2016; Fatade et al 2013; Itodo, 2019; Klegeris & Hurren, 2011; Mambwe & Overson, 2020; Nbina & Joseph, 2011; Neşe & Neşe, 2014; Ntibi & Neji, 2018; Obochi, 2021; Ogweno et al 2021; Omaga, Iji, & Adeniran, 2017; Osuafor & Orji, 2017; Semeneh, 2020) who revealed that there was significant difference ($p < 0.05$) in performance of students between control and the experimental group; in favour of the experimental group taught with PBL. The finding also correlates with Bawa (2014) who found that there was significant difference between the posttest mean scores of the experimental and control group of recall variable in Ecology in favour of the experimental group. The finding is also in support of Mandina and Ochonogor (2018) who revealed a statistical significant difference in the performance of students taught using the two problem-solving strategies and those taught using the lecture-based method. This may have resulted from PBL environment that allowed the learners to explore knowledge themselves to solve problems through critical thinking, creative, and problem solving skills to bring solutions to these problems which helped in improving their performances; unlike LBL environment that were passive learners.

Also, in testing the hypothesis as regards the gender difference on the effect of PBL on students' performance in Chemistry; the finding further revealed that there is no significant difference in performance in Chemistry of male and female students taught using problem-based learning. The performance of female and male students in the treatment group was not found to be statistically significantly different. Literature has reported findings by these researchers (Donnelly et al., 2012; Madsen et al., 2013; Richardson & O'Shea, 2013) revealing the exceptional performance of male students than their female counterparts in science. However, in the present study PBL reduced the gender gap on students' performance in Chemistry; indicating that gender is not a perfect predictor when gender-friendly strategy is used.

The finding is in agreement with Mandina and Ochonogor (2018) who found that the performance of students in the experimental group was not influenced by gender. The findings also supports Itodo (2019) who revealed that male and female students taught Biology in the experimental group equally benefited in performance from the PBL. The finding is also in line with Osuafor and Orji, (2017) who revealed that gender had no significant influence on performance in mathematics.

Contribution to Knowledge/Educational Implication

The findings of this study have added to established empirical evidences that PBL creates active learning environments and helps develop critical thinking skills, creativity and problem-solving skills in learners. Hence, helped in enhancing students' performances and developing positive attitudes towards chemistry.

The findings of this study had also established that the traditional teaching modes that has dominated science learning environments and has become a very serious issue does not enhance students' performance and attitudes in chemistry like PBL environment. In the LBL the learners are passive recipients; which might lead to discouraging students from becoming active in communicating their needs to their instructor. And, since the LBL method is based on memorizing which means the cognitive knowledge is much valued rather than the acquisition of skills.

The findings of this study have implications for chemistry teaching and learning in Nigeria. The findings of the study showed that the use Problem-based learning environment enhances the performance and attitude of students towards Chemistry more than the conventional lecture-based learning environment that is predominantly used in chemistry lessons. This, by implication, means that the use of lecture-based learning environment that is teacher-dominated and learners are passive recipients (memorizes more of chemistry concepts which does not retain for a long time) should be discouraged since it cannot lead to effective teaching of chemistry as well as students' high performance and positive attitudes.

Conclusion

This study reaffirms the previous studies which suggest that, the problem-based learning (PBL) enhances the students' performance and attitude toward Chemistry. Therefore, PBL is viable and has potential to enhance secondary school students' performance and attitude in Chemistry; since improved students' critical thinking and problem solving skills; than the lecture-based learning (LBL).

The teaching of Chemistry, using the PBL environment was found to have significant effect on students' performance and attitude toward Chemistry more than the LBL. But, the gender difference among students exposed to PBL was not significant implying that this mode of instruction is capable of facilitating learning in similar manner among male and female students in Chemistry. Hence, the use of PBL which is gender-friendly in chemistry lessons is cable of minimizing the issues of poor performances, attitudes and poor acquisition of skills (critical thinking, creativity & problem-solving skills) in learners than LBL were learners are passive recipients.

Recommendations

In view of the findings arising from present study, it is recommended that:

i. Chemistry teachers should be trained to create a friendly PBL environment in the teaching of chemistry at the secondary

school level since it enhances students' performance and attitudes towards the subject.

ii. Heads of Schools should help in sponsoring teachers to attend workshops and seminars on the appropriate and effective use of PBL in the realization of enhanced learning outcomes in Chemistry among secondary school students.

iii. Ministry of Education as an agency of government should also help to provide the needed instructional and infrastructural facilities to effectively implement PBL environment in secondary schools to promote meaningful learning.

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