

Facilitating Students' Mole Concept Self-Efficacy, Academic Performance and Knowledge Retention through Problem-Based Learning Model

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ABSTRACT

The study aimed to determine the effectiveness of Problem-based learning (PBL) on students' self-efficacy, academic performance and knowledge retention in mole concept at the secondary level. The study area was Jalingo Education Zone, Taraba State, Nigeria. The study adopted quasi-experimental research design. The population comprised all secondary school two (SS2) students offering chemistry from which a sample size of 135 students was drawn through purposive sampling from two intact classes. Students' self-efficacy scale (SSES) and Mole concept achievement test (MCAT) were tools used for data collection. Cronbach alpha and Kuder- Richardson KR-20 were used to estimate the reliability indexes of 0.815 and 0.745 for SSES and MCAT respectively. Analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The results revealed that there was a significant difference between the mean self-efficacy, academic performance and knowledge retention scores of students taught chemistry with PBL and Conventional Problem Solving; in favour of PBL. The study concluded that the use of PBL facilitated the learning of mole concept and enhanced students' academic performance, knowledge retention and self-efficacy. Thus, chemistry teachers should be trained on the use of PBL, specifically Krall's five-step PBL model in daily class lessons and on mole concept due to its effectiveness.

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INTRODUCTION

In the teaching-learning process, various teaching-learning strategies have been developed to accelerate learning process of students which evolved from the learning theories defining the role of teacher, students and the contents; but most behavioral practices in schools makes students passive and the classroom dominated by the teacher (Jack, 2022). Hence, for effective teaching to take place, the teacher should stimulate, encourage and maintain active participation of the students through the selection of appropriate teaching methods; which 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 either through innovative or traditional classrooms.

Traditional classroom as observed by Tighe (2020) in literature are classified into four key ways: i) has a competitive grading scale and traditional grading scale (a top achiever and a bottom achiever) which uses specific numbers, noting that the higher number is the better number, and focuses on specific answers or one correct answer; ii) are teacher-led, typically delivering information in the form of a lecture; iii) isolate one subject, teaching material that only pertains to that particular subject within the class

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period; and iv) has structured questions, meaning specific guidelines, directions, and rubrics are given to students to use during instruction. All these features are applicable in traditional learning environments and promotes more of rote learning since it is teacher-activity centered. Jack et al. (2017) noted that students' poor problem-solving ability, conceptual difficulties/misconceptions in some chemical concepts (such as the mole concept due to its abstract nature), and poor methods of instruction as amongst the factors identified with students' poor performance in chemistry despite its importance to mankind. Amongst the traditional learning environments is the Conventional Problem Solving.

The Conventional Problem Solving (CPS) is frequently a one – way process dominated by the teacher and unaccompanied by discussion, questioning or immediate practice; concentrates on information rather than learners, and the teacher tell the students what to do instead of activating them to discover for themselves. According to Zaidi et al (2017), the traditional learning classroom is based on memorizing which means the encyclopedic knowledge is much valued rather than the acquisition of skills, and 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 traditional learning classroom is more convenient for students who usually find it useful to have lecture notes that will help them in reviewing the topics prior to the test to get good grades.

Though, the traditional methods (lecture-based) could be less effective in helping the students in developing problem solving skills and understanding/mastery of chemistry concepts taught. However, problem-based learning (PBL) differs from these traditional classroom methods in four key ways; it is student-driven, teacher-facilitated, ill-structured, and cross-curricular (Brush, 2017; Tighe, 2020). Also, many traditional classrooms may not be providing opportunities to develop these essential skills however, incorporating problem-based learning can provide

schools a clear path to helping students achieve these vital 21st-century skills. And, as noted by Tighe (2020), although schools may recognize the value of a problem-based learning task, shifting from traditional methods into a PBL centered teaching approach may be difficult; but PBL learning help shifts a teacher-driven classroom into a student-driven classroom.

Problem-based learning can provide valuable student outcomes, both academically and socially, in the classrooms (Brush 2017; Saptura, 2019; Tighe, 2020); hence schools can begin to incorporate aspects of PBL into their curriculum to maximize student. Tighe (2020) noted that PBL is credited with many different valuable student outcomes, including increased motivation, collaboration, and long-term retention; however, previous research by Bijsman and Schakel (2018) suggested that outcomes may even surpass academics and positively impact discipline and attendance due to a high level of engagement in the classroom. Although all of these outcomes are important, Tighe (2020) also noted that there are three major outcomes of problem-based learning tasks that influence student learning, which is the development of critical thinking, flexible knowledge, self-directed learning skills; and these three outcomes can greatly impact student achievement, retention, self-efficacy and their success as a 21st-century learner.

Problem-based learning (PBL) is an alternative approach to teaching which is not prescriptive in nature and makes use of problem as a focus for student investigation and inquiry. Problem-based learning covers a broad family of schemes that include problem solving, project-based teaching, inquiry, case-based instruction and grounded instruction. Students' active involvement in trying to solve some problems or answer some questions is central to all the different strategies listed and students' self-efficacy beliefs. Students' underachievement and low self-efficacy as opined by Jimoh and Fatokun, (2020) towards learning especially difficult chemical concepts, can be attributed to some inadequacies in the teaching; and teachers' persistent adoption of conventional instructional

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approaches have been observed as a major challenge to students' proper understanding, assimilation and retention of content taught. The mole concept is a fundamental concept in chemistry though abstract in nature and mathematically inclined (Jimoh & Fatokun, (2020). Boniface (2018) affirmed the mole concept as a difficult concept and expressed students' wrong perception and exhibition of negative attitude towards its learning before exposure to treatment which has affected the learning outcomes and understanding of this fundamental chemistry concept.

One of the affective factors that determine the students' achievement and retention in the learning process is self-efficacy. Self-efficacy is described by Masitoh and Fitriyani (2018) as an individual's confidence about completing a variety of tasks, from understanding concepts to solving problems. Masitoh and Fitriyani (2018) noted that high self-efficacy will encourage the achievement of good learning outcomes, and when students have good learning outcomes, they will be more motivated in the learning process; and that students with high self-efficacy are able to solve a problem than students with low self-efficacy. However, studies that developed the PBL process in teaching chemistry mostly the mole concept and evaluated its effects, such as the enhancement of self-efficacy and problem-solving ability for improved performance and retention of chemical concepts are very few, and there exists a gap in the present study area (Taraba State). Thus, this study aimed to develop a PBL instructional package to help improve the problem-solving ability of students through integrative thinking and self-efficacy in mole concept which most students perceive as difficult, if it can help in the improvement in problem-solving ability.

Given the importance of the mole, a very fundamental mathematical concept in chemical reaction in chemistry; it is critical to concentrate on instructors' problem-solving abilities in order to achieve the necessary increase in students' learning outcomes mostly at the secondary level where there exist a serious gap in literatures. The problem of this study therefore is to find out if the

use of Problem-based learning strategy could enhance the self-efficacy, academic performance and retention in chemistry mostly in mole concept where there exists a gap. The objective of this study is to carry out a critical analysis of the effectiveness of Problem-based learning on students' self-efficacy, academic performance and retention in mole concept at the secondary level.

The study was guided with the following null hypotheses:

H0₁: There is no significant difference in self-efficacy of students taught mole concept in Chemistry using Problem-based learning and Conventional Problem Solving.

H0₂: There is no significant difference in performance of students taught mole concept in Chemistry using Problem-based learning and Conventional Problem Solving.

H0₃: There is no significant different in retention of students taught mole concept in chemistry using Problem-based learning and Conventional Problem Solving.

METHODOLOGY

This study adopted quasi-experimental design. The study area was Jalingo educational Zone Taraba State, Nigeria. The population was secondary school two (SS2) students offering chemistry in 2023/2024 academic session. A sample of 135 students in two intact classes (assigned as experimental & control groups) from two secondary schools, was selected using purposive sampling from the population, due to the nature of the study. The experimental group used an intact class of 71 students (40 males & 31 females); while the control group used an intact class of 64 students (29 males & 35 females). The control group used the Conventional Problem Solving (CPS); while for the experimental group used Problem-based learning (PBL).

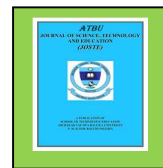
Two instruments, Students Self-efficacy Scale (SSES), and Mole concept Performance Test (MCPT) were used as data collection tools. The questionnaire (SSES) was adapted to measure students' self-efficacy in mole concept, and was used as pre-test and post-test for both experimental and control groups. The pre-test was

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used to measure students' self-efficacy towards mole concept before the exposure of the treatment to the experimental groups. On the other hand, the post-test was used to measure students' self-efficacy towards mole concept after the treatment. The items of the pre-test was re-arranged to form the post-test of SSES 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 the five point likert scale of SA=Strongly Agreed (5 points), A=Agreed (4 points), U= undecided (3point) D= Disagreed (2 points), and SD= Strongly Disagreed (1 point). The other instrument (MCPT) was administered to both control and experimental groups to measure their performance in mole concept. The MCPT was a 40 item 4-options multiple choice questions; where the right option is 1 and the wrong option is 0. The MCPT 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: mole concept, oxidation and reduction reactions, mass-volume relationship and electrolysis. This was to ensure equivalence of control and experimental groups. The post-test was used to measure the students' performance in mole concept for both experimental and control groups after the treatment.

The instruments 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 made by these experts were used to review the instruments.

To ascertain the reliability of the instrument, a pilot test was conducted in order to ensure consistency in the responses. A total of 30 students were used for trial-test both SSES and

MCPT. In determining the reliability of the SSES, 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 0.82 for the SSES. A response obtained from MCPT was used to test the reliability of the instrument using K-R formula 20 the reliability coefficient was 0.75. This indicated that instrument are reliable and suitable for the study.

The administration of the instruments were done in two phases; the first phase was a pre-test, which is administered to the students a week before the treatment. After the administration of the pre-test, the students were taught the selected topics for four weeks in the same intact classes. The teachers who participated in the study were regular teachers who serve as research assistants of the selected schools that taught both the experimental and the control groups respectively. The second phase was post-test was be done after the experiment to the determiner of the teaching strategy is effective. Both groups were taught for four weeks. At the end of the teaching, post-test was administered to the students in both the treatment and control groups. Retention test (Post-posttest) was administered to the students in the two groups two weeks after the post test. Data collected at pre-test, post-test, post post-test retention) were analyzed.

On the method of data collection, the preliminary stage took place in the first week; this included the presentation of an introductory letter for permission to be granted from the school authorities to use their students and teachers for the period of seven (7) weeks. The training of the research assistants (regular teachers) that were to handle the experimental and control groups in the various schools lasted for one week. The second week was used for the administration of pretest using both SSES and MCPT to both experimental and control group in the school for the period of one week. The third to six week was used for treatment for both the experimental and control groups.

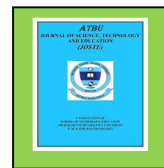
For the treatment, the control group used the Conventional Problem Solving (CPS). In

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the CPS class environments which is traditional, students' organization of knowledge was step by step solutions of given or restricted problems on mole concept. The focus on knowledge was largely proportional ignoring practical activity aspects (passive learners). The role of students in class activities was bounded problem solver based on fixed rule (examples) provided by the teacher; who was to judge the right knowledge and solutions of the problem since student type of activity is parroting-based exercise for finding solutions to given problems which is done mostly by memorization (role learning). While for the experimental group used Problem-based learning (PBL), specifically Krall's five-step PBL model. The PBL class environment was more innovative were the students were the origination of knowledge and used open-ended questions and situations, and focused on contingent and constructed matters. The students were active learners and independent critical inquirers who own their own learning experiences and the teacher was the enabler of opportunities for learning. The class activities helped the students in developing strategies to facilitate team and individual learning in order to promote meaningful learning.

While the 7th week was used for revision, completion of selected topics and administration of the post-test using reshuffle MCPT to both the experimental and control group. For the method of data analysis for the data collected, 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.

Krall's five-step PBL model

The study adopted problem-based learning, specifically the Krall's five-step Problem-based learning model (Krall, 2012) as treatment for the experimental group taught mole concept in chemistry which is also mathematical in nature.

Steps in Krall's PBL (Krall, 2012):

1. Posing the problem: Brainstorming to develop critical thinking skill
2. Peer interaction and working on the problem through collaborative, motivational and analytic learning to help develop collaborative and problem solving skills
3. Intervention as a question arises with guided practice (perceiving & processing)
4. Students apply the instruction and share their solution with adequate feedback
5. A solution reached, problem solving and critical thinking skills were developed.

An example of Krall's five-step PBL model in mole concept:

1. Posing the problem: E.g. Calculating the number of moles, and number if atoms of H, S, and O in 5 mole of H_2SO_4 .
2. Peer interaction and working on the problem to calculate the number of moles and atoms. Students brainstorms to find answer(s) to the problem collaboratively. 1 mole of H_2SO_4 contains 2 mole of H, 1 mole of S, and 4 mole of O
 \Rightarrow 5 mole of H_2SO_4 contains
3. Intervention as a question arises through guided practice as the students brainstorms 1 mole of H = $1 \times 6.022 \times 10^{23}$
4. Students apply the instruction and share their solution with adequate feedback
 10 mole of H = $10 \times 6.022 \times 10^{23}$
 5 mole of S = $5 \times 6.022 \times 10^{23}$
 20 ole of O = $20 \times 6.022 \times 10^{23}$
5. A solution reached, collaborative, critical thinking & problem solving skills developed

Solution:

10 mole of H = $10 \times 6.022 \times 10^{23} = 6.022 \times 10^{24}$ H atoms

5 mole of S = $5 \times 6.022 \times 10^{23} = 3.011 \times 10^{24}$ S atoms

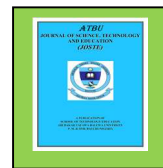
20 mole of O = $20 \times 6.022 \times 10^{23} = 1.204 \times 10^{25}$ O atoms.

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Also, an example of students' class activities using the Krall's five-step PBL model

during the administration of treatment is presented as follows:

Students Activities

Instructional strategy - Krall's Five-step PBL

Students are presented with a problem which is complex ill-structured concerned with real world phenomena on chemical reactions (mole and stoichiometry). Such problems engaged the students as an independent critical inquirer. Students brainstorm, interact, connect and discuss on the question which help to arouse their interest and self-efficacy in the lesson. Students listen, interacts, brainstorm, and identify different definition of moles and mole concept.

STEP 1: Posing the problem: Brainstorming to develop critical thinking skill

Students work on the small and interactive group for sharing and organizing their ideas including the past and present current state of knowledge and experience related to given problem. The students analyze, work in group to solve the open-ended problem. The student define mole and mole concept.

STEP 2: Peer interaction and working on the problem: Through collaborative, motivational and analytic learning to help develop collaborative and problem solving skills.

The students derive the formula for calculating mole. They calculate using different formulas. Students learn by doing something new whereas the tutor provides the series of arising conundrum in the cordial ways so that students employ the rules to find the proper solutions.

STEP 3: Intervention as a question arises: With guided practice (perceiving & processing) to develop independence and active engagement

The students get more examples to calculate based on the mole concept, with balanced chemical equation. The students modifies, adapts, and create more examples through the guidance of the teacher carrying out the calculation on mole concept; and share their solution with adequate feedback.

STEP 4: Students apply the instruction and share their solution with adequate feedback.

The students answer the question based on personal experiences, the student also asks question, and solves more calculations on mole. Students were allowed to brainstorm, interact and solve problems based on the mole concept.

STEP 5: A solution reached and problem solving and critical thinking skills developed.

RESULTS

Hypothesis One

H₀: There is no significant difference in self-efficacy of students taught mole concept in

Chemistry using Problem-based learning and Conventional Problem Solving.

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Table 1: One-way Analysis of Covariance of Mean Self Efficacy scores of the Problem-based learning and Conventional Problem Solving

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	0.759 ^a	2	0.480	0.680	.0505	.660
Intercept	55.150	1	35.145	210.120	.000	.550
Pre Self-efficacy	8.664	1	8.664	0.080	.772	.001
GROUP	0.662	1	0.662	1.355	.002	.018
Error	18.850	132	18.850			
Total	915.000	135				
Corrected Total	18.650	134				

a. R Squared = .662 (Adjusted R Squared = .656)

Table 1 is one-way ANCOVA between groups' analysis of covariance to compare the effect of Problem-based learning (PBL) and Conventional Problem Solving (CPS) on students' Self Efficacy in chemistry. The result $F(1, 132) = 1.355, P = .002 < 0.05$ shows that the two groups do differ significantly. Thus, the null hypothesis is rejected. Therefore, there is a significant difference between the mean self-efficacy scores of students taught chemistry with PBL and students taught with CPS; in favour of PBL. The effect size (eta square = .018) indicates that 18%

of the difference in the mean score is based on the strategy used. Since the probability value of .002 is less than the 0.05 level of significance ($p < .05$), the null hypothesis (H_0_1) was rejected.

Hypothesis Two

H0₂: There is no significant difference in performance of students taught mole concept in Chemistry using Problem-based learning and Conventional Problem Solving

Table 2: One-way Analysis of Covariance of the Mean Performance Scores of the Problem-based learning and Conventional Problem-Solving

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6340.819 ^a	2	3170.410	144.074	.000	.661
Intercept	22835.529	1	22835.529	1.038E3	.000	.875
PrePBL	15.007	1	15.007	.682	.410	.005
GrpCPS	6318.194	1	6318.194	287.120	.000	.660
Error	3256.797	132	22.005			
Total	321796.000	135				
Corrected Total	9597.616	134				

a. R Squared = .661 (Adjusted R Squared = .656)
 Dependent Variable: PostPBL-CPS

Table 2 is one-way ANCOVA between groups' analysis of covariance to compare the

effect of Problem-based learning and Conventional Problem Solving on students'

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performance in chemistry. The result $F(1, 132) = 287.120$, $P = .000 < 0.05$ shows that the two groups differ significantly. Thus, the null hypothesis is rejected. Therefore, there is a significant difference between the mean performance scores of students taught chemistry with Problem-based learning and students taught with Conventional Problem Solving. The effect size (eta square = .660) is high and it indicates that

66% of the difference in the mean score is based on the strategy used.

Hypothesis Three

H0₃: There is no significant difference in retention of students taught mole concept in Chemistry using Problem-based learning and Conventional Problem Solving.

Table 3: ANCOVA of Retention of Students taught Mole concept using the Problem-based learning and Conventional Problem Solving.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	165.390 ^a	2	82.695	4.344	.014	.039
Intercept	4108.501	1	4108.501	215.845	.025	.501
Pre MCPT	32.358	1	32.358	1.700	.194	.008
Strategy	97.311	1	97.311	5.112	.000	.223
Error	4092.413	132	19.034			
Total	28969.000	135				
Corrected Total	4257.803	134				

a. R Squared = .039 (Adjusted R Squared = .030)
Dependent Variable: Retention

Table 3 is one-way ANCOVA between groups' analysis of covariance to compare the effect of Problem-based learning (PBL) and Conventional Problem Solving (CPS) on students' retention in chemistry. The result $F(1, 132) = 19.034$, $P = .000 < 0.05$ shows that the two groups differ significantly. Thus, the null hypothesis is rejected. Therefore, there is a significant difference between the mean retention scores of students taught chemistry with PBL and students taught with CPS. The effect size (eta square = .223) is high and it indicates that 22% of the difference in the mean score is based on the strategy used.

DISCUSSION OF FINDINGS

The key findings to be discussed includes:

1. There is a significant difference between the mean self-efficacy ratings of students taught chemistry with Problem-based learning (PBL) and students taught with Conventional Problem Solving; in favour of PBL.

2. There is a significant difference between the mean performance scores of students taught chemistry with Problem-based learning (PBL) and students taught with Conventional Problem Solving; in favour of PBL.
3. There is a significant difference in retention of students taught mole concept in chemistry using Problem-based learning (PBL) and Conventional Problem Solving; in favour of PBL.

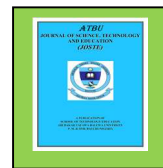
These key findings are discussed in three categories; effect of instructional strategies on students' self-efficacy, academic performance, and knowledge retention as follows: The finding based on the effect of instructional strategies on students' self-efficacy showed that; there was a significant difference between the mean self-efficacy ratings of students taught chemistry with Problem-based learning (PBL) and students taught with Conventional Problem Solving; in favour of PBL. The findings agree with Choi et al. (2022), who revealed that the self-efficacy of

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learners were improved in the class to which PBL was applied. It also agrees with Jimoh and Fatokun (2020) who revealed that students taught mole concept using PBL strategy perform better and expressed better interest than those taught using lecture method. The finding agrees with Handayani and Louise (2019) who revealed the effectiveness of PBL in chemical equilibrium topic; the result indicated that student's self-efficacy in PBL model achieved good category. The higher score of students' self-efficacy contained in indicator overcome the difficulties, complete the assignment, solve the problem, getting good result, apply efficacy in daily life, cooperate and communicate in team.

The finding also agrees with Masitoha and Fitriyani (2018) who revealed that the PBL approach could improve student's mathematics self-efficacy. At the end of the first cycle, the students' mathematics self-efficacy was still in the medium category and increased at the end of the second cycle, which students' mathematics self-efficacy has been in high category. It agrees with Mataka, (2014) on the effectiveness of PBL on students self-efficacy beliefs; and indicated that PBL has a potential for improved students' outcomes in the affective domain including attitudes toward chemistry and self-efficacy beliefs. However, it contradicts Zaidi et al. (2017) whose result showed there was no difference on self-efficacy for both groups of PBL and the traditional teaching method.

The finding based on the effect of instructional strategies on students' academic performance showed that; there was a significant difference between the mean performance scores of students taught chemistry with Problem-based learning (PBL) and students taught with Conventional Problem Solving (CPS); in favour of PBL. There was also a difference between the posttest mean scores of the two groups; which is in favour of the PBL group. The finding implied that the students taught chemistry with PBL gained in performance more than their CPS counterparts. This study agrees with these previous researchers (Agbidye, 2017; Aidoo et al, 2016; Choi et al., 2022; Cwynar, 2020; Handayani & Louise, 2019; Itodo, 2019; Jimoh & Fatokun, 2020; Mahasneh &

Alwan, 2018; Malla, 2020; Mambwe & Overson, 2020; Masitoha & Fitriyani, 2018; Omega et al., 2017; Tighe, 2020) whose studies were in favour of the PBL group that achieved more than their counterparts taught in traditional class environments. The findings also agrees with Choi et al. (2022), who revealed that the problem-solving ability of learners were improved in the class to which PBL was applied. The finding also agrees with Dorji (2021) who revealed the effectiveness of using PBL on the academic achievement of higher secondary school students. The results revealed that the experimental group that used PBL scored higher marks in the class test than the control group. The experimental group had a favorable opinion on the effectiveness of the PBL strategy.

Nenshi et al (2021) also revealed the effectiveness of PBL; the finding revealed among others that students taught with PBL recorded higher interest, achievement and expanded their low cognitive load compare to their counterparts taught using lecture method. It also agrees with Jimoh and Fatokun (2020) who revealed that students taught mole concept using PBL strategy perform better and expressed better interest than those taught using lecture method. Cwynar (2020) also attested to the effectiveness of PBL on students' achievement; and findings showed that there was a statistically significant weak positive correlation between the degree of PBL implementation and the students' academic achievement. The finding also agrees with Wahyu et al (2018) whose results showed that generally academic achievement and creativity of students increased with PBL and that it can be applied on the learning process for other chemistry topics that are suitable in terms of characteristics between learning materials and PBL stage. And, the results by Zaidi et al. (2017) showed strong positive correlation of self-efficacy and performance.

The finding based on the effect of instructional strategies on students' academic knowledge retention showed that the mean retention gain for PBL was higher than Conventional Problem Solving group; and the difference was significant in favour of the experiment group (PBL). The difference in

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knowledge retention of secondary students taught Mole concept using PBL and Conventional Problem Solving was in favour of students in PBL class. This study agrees with the studies conducted by these previous researchers (Dorji, 2012; Itodo, 2019; Klegeris & Hurren, 2011; Mataka, 2014) whose studies were in favour of PBL group. It also agrees with Klegeris and Hurren (2011) who also indicated that students using PBL had better responses to problems and had better plans for solving their problem than the control group.

Chin and Chia (2006) found that the use of ill-structured problems in PBL elicited desirable successes in students' cognitive processing that are essential for good problem solving. Students were able to formulate research problems, pose questions, design and conduct investigations, make explanations, and propose alternative ideas through brainstorming. Chin and Chia (2006) also noted that PBL prepare students for real world challenges, provided opportunities for alternative ways to attain a solution for their problems since it usually encouraged "self-directed learning, active engagement, and generalization, multiplicity of ideas, reflectivity, personal relevance, and collaboration".

In overall, the positive impact of PBL on students' self-efficacy, academic performance, and knowledge retention had ascertained its input in learning and skill development. It showed that PBL is an instructional method that aims for more learning targets than that of traditional instruction (conventional problem solving). Along with strengthening content knowledge, the use of PBL in the mole concept class lessons focused on the development of innovative skills, higher order thinking, metacognition, and motivation. The structure of PBL applicable in Krall's five-step model helped in promoting learning opportunities that are interdisciplinary and student-centered. The instructional strategy also allowed the students to engage with one another in real-life learning situations giving them the opportunity to work together, and construct knowledge on their own, and reached a solution of the problem posed before them more easily. The students in the experimental group that used PBL were

extensively and actively engaged; and the strategy provided them with autonomy while exploring phenomena and allowed them to take more responsibility for their own learning. And, because of the PBL class environment used by the experimental group which was being driven by the student, it help impact their overall awareness of their own understanding and may have also improved their own motivation (Ali et al., 2011) hence aftermath of positive impact on their performance, retention and self-efficacy.

CONCLUSION

Based on the findings, the study concluded that the use of Problem-based learning (PBL) facilitated the learning of chemistry, particularly the mole concept. The strategy (PBL) enhanced students' academic performance, knowledge retention and self-efficacy more than the traditional mode of instruction (conventional problem solving). Hence, if PBL is adopted in chemistry, it may help improve the academic performance, knowledge retention and self-efficacy of students in the teaching-learning process of some difficult topics in chemistry such as the mole concept.

RECOMMENDATIONS

Based on the conclusion drawn from the findings of this study, it is hereby recommended that:

1. Chemistry teachers should be trained and encouraged to use problem-based learning in making daily lesson plans in teaching difficult chemistry concepts such as mole in order to improve the performance, enhance knowledge retention of previously gained concepts, and promote higher self-efficacy in students.
2. The PBL model may be applied on the learning process for other chemistry topics that are suitable in term of characteristics between learning materials and PBL stages in order to develop academic performance, knowledge retention and self-efficacy of students.

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3. Curriculum planners and science teachers may be innovative and adopt a problem-based learning in teacher education instructions since the students are actively engaged and develop the 21st century skills such as collaboration, critical thinking and problem solving. Hence, its use is highly recommended in the teaching of some difficult mathematical concepts in chemistry such as the mole concept and other chemical concepts.

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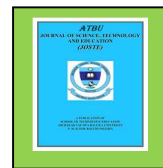
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