Improving Students' Attitude and Achievement in Stoichiometry Using Problem-Based Learning Approach in Jos, Plateau State

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ABSTRACT

This study investigates the effects of problem-based learning (PBL) on students' attitude and achievement in stoichiometry in Jos, Nigeria. The research was of a pretest–posttest control group quasi-experimental design with a sample of 86male and female students grouped into experimental and control groups. A Stoichiometric Achievement Test (SAT, r = 0.79) and a Stoichiometric Attitude Questionnaire (SAQ) were used as instruments. A pretest was administered to both groups and the topic (stoichiometry) taught with PBL in the experimental group and with lecture method in the control group for four weeks after which a posttest was administered. The research questions were answered using mean and standard deviation while the hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. Results show that students taught using problem-based learning approach had a more positive attitude and performed significantly better than their counterparts taught with conventional lecture approach. The result also revealed no significant difference between male and female students' attitude, towards stoichiometry. The result further revealed no significant difference between male and female students' achievement in stoichiometry. PBL approach provided equal opportunities in the learning process for male and female students to benefit maximally when taught stoichiometry using the approach. The study recommended the adoption of PBL approach by Chemistry teachers since it has been found to be effective in enhancing students' attitude and achievement compared to lecture method. Government and school proprietors should encourage the training and re-training of Chemistry teachers on how to incorporate effectively problem-based learning approach during chemistry lessons.

Keywords: Attitude, Achievement, Stoichiometry, Problem-based Learning

INTRODUCTION

Teaching is the process of imparting knowledge, skills, and values to others. It involves the sharing of information and ideas to facilitate learning and understanding. It is an interpersonal influence aimed at changing the behavior potential of learners. Effective teaching involves the use of appropriate methods and strategies to engage learners, facilitate their learning, and help them achieve their learning goals (Aidoo, Boateng, Kissi & Ofori, 2016). The teaching and learning of science have seen various transformations which gives teachers and students opportunities to develop positive attitudes towards science as a subject and to make learning of science less stressful but more practicable and meaningful. Learning science in the 21st century aims at training students to be able to understand concepts, develop process skills and also develop thinking abilities to be able to transfer knowledge. Good teaching is essential for the development of individuals and society as a whole, as it helps to foster critical thinking, creativity, and innovation.

Reforms in science education as reflected in the national curricula and policies of different nations, place greater emphasis on the need to graduate students who will be able to function effectively in a scientific and technological society (Upahi, Gbadamosi, Boniface, 2017). The Nigerian national policy on science education emphasizes the teaching and learning of science processes and principles; which are anticipated to lead to fundamental and applied research in the sciences at all levels of education (Federal Republic of Nigeria, 2013). One common features of these national science education reforms among different countries, is the emphasis

on the need for students to understand the interactions among science, technology, and society and be able to use this knowledge in their day-to-day decision-making processes.

In science teaching, the student must not only learn to understand the concepts of science but use the scientific inquiry to develop the ability to think and act in ways that are related with inquiry. Teachers are to equip learners with knowledge, skills and values that help in meaningful participation irrespective of intellectual ability, race, gender, and socio-economic background (DBE, 2011). They are to help students to promote knowledge and skills through scientific inquiry and application of scientific knowledge. This could be achieved by encouraging students to engage in an active learning, rather than rote learning.

Science and technology education has been noted for its tremendous contribution as the driving force for the development of nations. Chemistry particularly, has been identified as a very important science subject and its importance in scientific and technological development of nations has been widely reported. Chemistry occupies a pivotal position in science and technology and is considered as the hub of science and it is considered as a service subject (Jamil & Mahmud, 2019). It has helped in the development of modern technology through the application of its principle in modern invention. It fundamentally combines with other science subjects such as physics, and biology to guarantee learners admission into higher institutions as a prerequisite subject for offering most science-oriented courses such professions as, medicine, pharmacy, dentistry, agriculture, home economics, food science, engineering, among others, in the tertiary institutions (Nja, Orim, Neji, Ukwetang, Uwe & Ideba, 2022).

However, despite the numerous contributions of chemistry to national development, students' achievement in the subject over the years in both internal and external examinations have been poor. Achievement here refers to measurable performance of students in academic tasks, often quantified through tests scores or grades in the context of mastering specific concepts. It is the measurable outcome of students' performance in chemistry examinations typically reflected in their scores and grades. In the West African Senior School Certificate Examination (WASSCE) and the National Examination Council (NECO), a score of 50 and above is considered pass mark while any below 50 is a fail. Researchers such as Philip (2023), Gongden (2022), Nja, Orim, Neji, Ukwetang, Uwe and Ideba (2022), Nja, Cornelius-Ukpepi and Ihejiamaizu (2019) and Nja, Cornelius-Ukpepi and Orim (2019) have all reported the poor achievement of students in the WASSCE and NECO. The West African Chief Examiners' reports (2017-2022) also give a number of concepts that students found difficult and abstract, and so performed poorly to include: chemical equilibrium, particulate nature of matter, chemical bonding, stoichiometry, periodicity of elements, chemical kinetics, energy changes, and nomenclature of organic compounds among others. Stoichiometry is the relationships between the amounts of reactants and products before, during and after chemical reactions. It is the determination of the proportions in which elements or compounds react with one another. For example, in the balanced equation:

$N_2 + 3H_2 \rightarrow 2NH_3$

Nitrogen reacts with hydrogen to form ammonia in the ration 1:3:2. That is, 2moles of nitrogen gas is required to react with 3 moles of hydrogen gas to form 2 moles of ammonia gas. This statement expresses the stoichiometry of the reaction.

Various reasons have been given for the poor achievement of students in chemistry. One of such is that most students also perceive chemistry as a difficult and abstract subject and so are they are not committed to study the subject which has resulted in the development of negative attitudes towards the subject. Unfortunately, most parents who have no idea about the subject but want their children to become nurses or doctors do insist that their children offer the subject. Other challenges including the lack of resources such as teaching aids, teacher qualification, teachers' interest, large class size; pupil-teacher ratio and materials for the practical lessons tend to force teachers to deliver the lessons theoretically (Aidoo, Boateng, Kissi & Ofori, 2016). Most teachers ignore the practical lessons due to time constraints (Ogula & Onsongo, 2009). This is so because the syllabus is structured in such a way that a certain scope must be covered before the termly examinations and considering the fact that practical lessons take a lot of time to organize and deliver, they prefer to teach it theoretically. In addition to the above, other factors responsible for students' poor performances in science are lack of content knowledge by teachers and the use of inappropriate or ineffective teaching strategy by

chemistry teachers. Teaching strategy is a variable that can easily be manipulated by teachers to increase student's achievement and retention rate. Therefore, in order to improve the achievement of students in chemistry and other physical sciences, a more engaging teaching strategy needs to be employed by the teacher. One of these strategic teaching methods is the Problem based Learning (PBL) approach.

Problem based learning (PBL) is a type of learning which involves problems that give students opportunity to design an investigative activity using problem-solving to arrive at a conclusion (Aidoo, Boateng, Kissi & Ofori, 2016). PBL as an instructional method helps students to use open-inquiry approach in learning to apply scientific knowledge in real life situations unlike the traditional method where students become passive in the teaching process that does not promote problem-solving and cognitive skills. According to Erdogan and Senemoglu (2017), PBL is a student-centered approach, which has its roots in constructivist epistemology. It begins with the introduction of an ill- structured problem, where teachers act as facilitators and learners actively construct knowledge by defining learning goals, seeking information to build upon prior knowledge, reflecting on the learning process and participating actively in cooperative/collaborative learning groups. PBL is a student-centered instructional approach in which complex real-world problems are used as the vehicle to promote students' learning of concepts and principles. As an instructional method, it reflects active learning and constructivist philosophy, incorporating multiple instructional strategies to help students acquire and apply content knowledge and develop higher-order thinking, problem-solving, self-directed learning, and collaborative skills (Hung & Amida, 2020). These instructional strategies include problem-initiated/problem-driven instruction, real-life complex ill-structured problems, self-directed learning, and collaborative small group learning. PBL is also highly effective in cultivating students' soft skills, such as collaboration, teamwork, professionalism, and workplace culture where traditional lecture-based instruction falls short. PBL is an effective pedagogy for preparing the next generation of scientists as well as promoting science literacy among general education students. With PBL, science is no longer a matter of memorizing scientific terms, definitions, formulae, and algorithms for solving abstract problems. Rather, PBL makes science part of everyday life.

PBL is a student-centered instructional approach that is applied at many educational institutions. The PBL process does not focus on solving problems with definite solutions; instead, it allows for the development of other desirable skills and attributes, including knowledge acquisition, enhanced team collaboration, and communication (Wang & Zhao, 2021). In PBL, students learn by solving problems and reflecting on their experiences. As such, PBL is well suited to helping students become active learners, because it situates learning in the realm of real-world problems and makes students responsible for their learning. In PBL, students work in small collaborative groups and learn what they need to know to solve a problem. The teacher acts as a facilitator to guide the students in developing the cognitive skills required for problem solving and collaboration.

One of the variables that affects learning outcome is attitude. Attitude is a psychological construct that reflects an individual's favorable or unfavorable evaluations, feelings, and tendencies towards a particular subject, and in this case, the concept of stoichiometry. It can be seen a supporting tool that informs teachers, policymakers, and researchers of the needs for raising interest in learning a certain subject, such as physics. Students' attitude towards learning can affect their success (Sirait, Balta & Mason, 2017). In this regard, research by Nteere, Kwaria and Kirimi (2017), pointed out that the method of instruction employed by a teacher influences students' attitude towards the subject. However, research on how methods of instruction such as PBL effect the attitudes of students are limited. This study also aimed to determine the effect of PBL on students' attitudes towards chemistry.

Gender difference in Chemistry achievement has been an issue of concern to chemical educators. Several research findings on gender and students' attitude and achievement in chemistry exist with different opinions and findings. Studies conducted by science educators on the relationship between gender and students' achievement (and attitude in some cases), have been inconsistent (Ezinwa, 2021). While some studies show that male students achieve more than female students (Okeke & Ikokwu, 2017), some studies put female students ahead of males. Yet there are findings that show that there is no significant difference between the achievement and attitude of male and female students.

THEORETICAL FRAMEWORK

Problem-Based Learning (PBL) has a rich theoretical foundation rooted in several educational and cognitive psychology theories. One of the key theoretical underpinnings is the Constructivist Theory. The constructivist theory has its roots in the works of several philosophers and psychologists, but the key founders include Jean Piaget (1896-1980), a Swiss psychologist who is widely regarded as the founder of constructivist theory. Piaget's work focused on how children construct their understanding of the world through active learning and experience. Another is Lev Vygotsky (1896-1934), a Russian psychologist who emphasized the role of social interaction and language in shaping cognitive development. This theoretical foundation informs the design and implementation of PBL approaches, emphasizing learner-centered, experiential, and collaborative learning experiences.

LITERATURE REVIEW

Various studies have shown that PBL is effective in learning. In a study aimed at determining the effects of problem-based learning (PBL) on student performance and attitude toward chemistry, Charif (2010) found out that implementing the problem-based learning approach had improved students' achievement and attitude. This study recommends that teachers implement problem-based learning in teaching science concepts especially chemistry for middle school students. Aidoo, Boateng, Kissi and Ofori (2016) found out a significant difference in the achievement between the students' performance in the post- test after they were exposed to PBL and traditional instructional approach of teaching chemistry. The students in the experimental group performed very well after the study as compared to the control group. It shows that the student's problem-solving skills and thinking abilities had improved when the PBL instructional method was used in teaching Chemistry.

Günter and Alpat (2017) carried out a study on the effects of problem-based learning (PBL) on the academic achievement of students studying electrochemistry. In it, they found out that there was a positive and very high level of statistically significant correlation between the scores in the post-test and the scores obtained from the open-ended questions of the students in the experimental group. They concluded that students in the experimental group were better able to understand the topic and its structure compared to the students in the control group. At the end of the application, the results of semi-structured interviews carried out showed that students in the experimental group had positive opinions regarding PBL. Aaron, Crocket, Morrish, Basualdo, Kovithavongs, Mielke and Cook in Aidoo, Boateng, Kissi and Ofori (2016) found a higher examination scores in students who enrolled in PBL class as compared to traditional method and recommended that the type of questions asked should relate to the concept and have dispersed knowledge. Chileya and Shumba (2020) in a study on the impact of problem-based learning on learners' academic achievement in chromatography and science learning activation found that learners in the experimental group showed improvement in achievement more than those in the control group. Shehu (2015) also found that students taught using problem-solving performed significantly better than those taught through lecture method when he investigated the use of problems-solving and its effect on student achievement in the mole concept. The results revealed that problem-based learning had a positive impact on learners' academic achievement and science learning activation. Ayyıldız and Tarhan (2018) established that PBL is an effective active learning approach that enhances achievement and prevents the formation of alternative conceptions, conceptual difficulties and lack of knowledge among 11th-grade students with respect to enthalpy changes in systems. Their results suggest that if PBL were more widely applied in classes, students would acquire the skills necessary to be successful in life.

According to Ibrahim (2019), students' negative attitude towards physics positively corresponds to low students' achievement in the subject. Assessing students' attitude is crucial for adapting to appropriate instruction. Teachers and researchers are therefore advised that improving students' attitudes and beliefs about a subject helps them more successfully learn the subject's content and helps develop their ability to think appropriately. Demirel and Dağyar (2016) investigated students' attitudes toward courses supported by problem-based learning and found out that problem-based learning is effective in helping students gain a positive attitude toward courses. In a study on the effect of problem-based learning on students' attitude towards learning physics, found that both problem-based learning and traditional instructions caused a

statistically significant positive effect on students' attitudes towards physics. However, the experimental group gained more positive attitude than the control group as they were more inclined towards the expert-like attitude than their counterparts due to the problem-based learning approach they learned in. Okorie and Eze (2016) found that females achieve higher than males in Chemistry. Babale, Lawal, Ibrahim (2019) however, found no gender difference in the achievement of male and female students in Chemistry. The method of instruction such as PBL has been found to be one of the causes of gender related differences in Chemistry achievement (Egolum & Igboanugo, 2017).

Generally, the use of the PBL strategy in teaching also helps to stimulate students understanding on how to find information that are linked to the problem and this increases their thinking ability (Aidoo, Boateng, Kissi & Ofori, 2016). The teacher only guides the students throughout the learning process whilst the students take responsibility of their own learning to come up with a solution. Furthermore, it motivates students to learn and develop independent skills to enable them solve problems and face challenges in their real-life situations.

Problem Of the Study

The poor achievement of students in chemistry examinations has largely been attributed to the poor or ineffective teaching strategies employed for the teaching and learning of chemistry. Studies such as those by Philip (2023), Gongden (2022), Nja, Orim, Neji, Ukwetang, Uwe and Ideba (2022), and Nja, Cornelius-Ukpepi and Orim (2019) have all reported the poor achievement of students. Even when students are exposed to strategies such as demonstration, discussion, inquiry, etc, schools keep graduating students with poor results. However, problem –based learning strategy has been found to be a more effective approach of teaching chemistry. The use of the strategy has been found to improve students' achievement. The use of PBL puts the students' responsibility in their own work can enable teachers to monitor students understanding and the development of a self-regulated learning. It has also been found to improve the attitude of students towards some courses. However, very little or no empirical reports exists on the effects of problem-based learning on students' attitude and achievement in stoichiometry especially in Plateau state. In view of this and the existing controversy, there is the need to find out the effects of PBL on male and female students' attitude and achievement in stoichiometry in secondary schools in Jos metropolis, Plateau state - Nigeria.

Aim And Objectives of The Study

The aim of this study is to find out the effects of PBL on students' attitude and achievement in stoichiometry in Jos Metropolis. Specifically, the study sought to:

1. find out how the attitude mean score of students in the control differ from those in experimental group before the treatment.
2. determine the difference between the posttest achievement mean scores of the control and experimental groups
3. determine the difference between the attitude mean scores of the students in the control and those in experimental group after the treatment.
4. find out if the posttest achievement means scores of male students differ from that of female students in the experimental group.

Research Questions

In order to achieve the objectives of this study, the following specific research questions are raised to guide the investigation:

1. What is the difference between the attitude mean score of students in the control and those in experimental group before the treatment?

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2. What is the difference between the posttest achievement mean scores of the control and experimental groups?

3. What is the difference between the attitude mean scores of the students in the control and those in experimental group after the treatment?

4. What is the difference between the posttest achievement mean scores of male and female students in the experimental group?

Research Hypotheses

The following null hypotheses will be tested at 0.05 level of significance:

1. There is no significant difference between the attitude mean score of students in the control and those in experimental group before the treatment.

2. There is no significant difference between the posttest achievement mean scores of the control and experimental groups.

3. There is no significant difference between the attitude mean scores of the students in the control and those in experimental group after the treatment.

4. There is no significant difference between the posttest achievement mean scores of male and female students in the experimental group

METHODOLGY

The researcher employed the quasi-experimental design, and specifically, the pretest-posttest-control group design in order to determine the effect of PBL on students' attitude and achievement in stoichiometry. Intact classes were randomly assigned to the experimental and control groups.

To assess the effectiveness of PBL application, two instruments were used: Stoichiometric Achievement Test (SAT) and a Stoichiometric Attitude Questionnaire (SAQ). The SAT consisted of 25 standardized multiple choice objective questions drawn from the concept stoichiometry. The SAQ consisted of ten statements linked to a four - point Likert-type scale ranging from (4) strongly agree to (1) strongly disagree.

The sample consisted of 86 students with 41 (22 male and 19 female) students in the experimental class, and 47 students (24 males and 21 females) in the control class. A pretest was administered to both groups before treatment. Similarly, an attitude questionnaire was administered to determine their attitude on entry. The students in the experimental group were taught the concept stoichiometry using the PBL strategy while the students in the control group were taught the same concept with the traditional lecture method of teaching. The treatment lasted two weeks after which a posttest was administered and the attitude questionnaire administered to determine their attitude after treatment. The scores were analyzed and the research questions answered using mean, and standard deviation while the hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The SAQ scores were analyzed using mean and standard deviation and ANCOVA to find whether there is any significant difference between the attitudes of the students in the two groups after treatment.

RESULTS

Research Question One: What are the pre-test and post-test attitude mean score of students in Stoichiometry in the experimental and control groups?

Table 1: Pre-test and post-test Attitude Mean Scores of Students in the Experimental and Control Groups

Group		Pre-test		Post-test			
	N	Mean	SD	Mean	SD	Mean Gain	$\bar{x}$- difference
Experimental		31.73	7.80	50.22	4.35	18.49	
							17.6
Control		30.44	7.96	31.33	9.92	0.89	

Table 2 reveals the pre-test and post-test attitude mean score of students in the experimental and control groups. In the experimental group the post-test attitude mean score was 50.22 and standard deviation of 4.35, higher than the pre-test mean score of 31.73 and standard deviation of 7.80 with a mean gain of 18.49, indicating that there was a change in the attitude of students after treatment. Also, for the control group the mean score was 30.44 and a standard deviation of 7.96 in the pretest. The post-test mean score of students rouse to 31.33 and a standard deviation of 9.92. The findings show that students in the experimental group had a higher mean score after treatment using problem-based learning approach than those in the control group who were not given treatment with a mean difference of 17.6. This means that at the pre-test the students in both groups had negative attitude, but after the intervention the experimental group had a more positive attitude towards stoichiometry than the control group. This implies that problem-based learning approach does change students' attitude positively towards stoichiometry.

Research Question Two: What is the attitude mean scores of male and female students in stoichiometry after exposure to problem-based learning approach?

Table 2: Post-test Attitude Mean score of Male and Female Students in the Experimental Group

Gender	N	Mean	SD	$\bar{x}$- difference
Male	22	50.32	4.213	
				0.21
Female	19	50.11	4.605	

Table 2 presents the post-test attitude mean score of male and female students in stoichiometry in the experimental group. From the result, the post-test attitude mean score of male students is 50.32 and a standard deviation of 4.21, while the female has an attitude mean score of 50.11 and a standard deviation of 4.61 with a mean difference of 0.21, indicating that there was an improvement in the attitude mean score of male and female students after treatment with male having almost same attitude mean score with the female students.

Research Question Three: What are the pre-test and post-test achievement mean score of students in Stoichiometry in the experimental and control groups?

Table 3: Pre-test and post-test Achievement Mean Scores of Students in the Experimental and Control Groups

Group		Pre-test		Post-test			
	N	Mean	SD	Mean	SD	Mean Gain	$\bar{x}$- difference
Experimental	41	28.88	6.71	65.07	17.24	36.19	

							19.79
Control	45	29.18	6.86	45.58	7.23	16.4	

Table 3 reveals the pre-test and post-test achievement mean score of students in the experimental and control groups. The post-test achievement mean scores of the experimental and control groups were 65.07 and 45.58 and standard deviations of 17.24 and 7.23 respectively, higher than the pre-test mean scores of 28.88 and 29.18 with standard deviations of 6.71 and 6.86 with mean gains of 36.19 and 16.4 respectively, indicating that there was an improvement in the achievement of students in both groups at the post -test. The findings show that students in the experimental group had a higher achievement mean score (65.07) after treatment using problem-based learning approach than those in the control group (45.58) who were not given treatment with a mean difference of 19.79. This means that at the pre-test the students in both groups had a poor achievement and were

almost at the same level, but after the intervention, the experimental group had a higher achievement in stoichiometry than the control group. This implies that problem-based learning approach does improve students' achievement in stoichiometry.

Research Question Four: What is the difference between the posttest achievement mean scores of male and female students in the experimental group?

Table 4: Post-test Achievement Mean score of Male and Female Students in the Experimental Group

Gender	**N**	**Mean**	**SD**	$\bar{x}$**- difference**
Male	22	69.68	16.439	
				9.94
Female	19	59.74	17.006	

Table 4 shows the post-test achievement mean score of male and female students in stoichiometry in the experimental group. From the result, the post-test achievement mean score of males is 69.68 and a standard deviation of 16.44, while the female has an achievement mean score of 59.74 and a standard deviation of 17.01 with a mean difference of 9.94, indicating that there was an improvement in the achievement mean score of male and female students after treatment with male having a higher achievement mean score than the females.

Hypotheses Testing

Hypothesis One: There is no significant difference in the attitude mean score of students in stoichiometry in the control and experimental groups.

Table 5: ANCOVA Result on Posttest Attitude Mean Scores of Experimental and Control Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7812.865[a]	2	3906.432	65.843	.000	.613
Intercept	10868.885	1	10868.885	183.195	.000	.688
Covariate	160.668	1	160.668	2.708	.104	.032
Group	7783.253	1	7783.253	131.187	.886	.612
Error	4924.356	83	59.330			

Total	152667.000	86				
Corrected Total	12737.221	85				
a. R Squared = .613 (Adjusted R Squared = .604)						

Table 5 indicates the Analysis of Covariance (ANCOVA) result on the significant difference in the attitude mean score of students exposed to problem-based learning approach and those not exposed. The table shows that $F(1,83) = 131.19$, $p < 0.05$, since the p-value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of problem-based learning approach on the attitude of students in stoichiometry. The result further reveals an adjusted R squared value of .604 which means that 60.4 percent of the variation in the dependent variable which is attitude towards stoichiometry is explained by variation in the treatment of problem-based learning approach, while the remaining is due to other factors not included in this study. This implies that problem-based learning approach can help improve students' attitude in stoichiometry.

Hypothesis Two: There is no significant difference between the posttest attitude mean scores of male and female students in the experimental group

Table 6: ANCOVA Result on Effect of Treatment on Male and Female Students Attitude to Stoichiometry in the Experimental Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.467[a]	2	.234	.012	.988	.001
Intercept	4623.051	1	4623.051	232.820	.000	.860
Covariate	.005	1	.005	.000	.987	.000
Gender	.412	1	.412	.021	.886	.001
Error	754.557	38	19.857			
Total	104157.000	41				
Corrected Total	755.024	40				

a. R Squared = .001 (Adjusted R Squared = .052)

Analysis of Covariance (ANCOVA) was conducted to determine if there is a significant effect of treatment on male and female students' attitude when taught stoichiometry using problem-based learning approach. Table 6 shows that the main effect of treatment on gender yielded $F(1,38) = .021$, $p > 0.05$, since the p value of 0.886 is greater than 0.05 level of significance, the null hypothesis was retained, indicating that there was no significant effect of treatment on the male and female students' attitude towards stoichiometry. The result further reveals an adjusted R squared value of .052 which means that 5.2 percent of the variation in the dependent variable which is attitude in stoichiometry is explained by variation in the gender, while the remaining is due to treatment and other factors not included in this study. It means that problem-based learning approach can help change the attitude of both male and female students towards stoichiometry equally.

Hypothesis Three: There is no significant difference between the posttest achievement mean scores of students in stoichiometry in the control and experimental groups.

Table 7: ANCOVA Result on Posttest Attitude Mean Scores of Experimental and Control Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8199.484[a]	2	4099.742	24.065	.000	.367
Intercept	14904.575	1	14904.575	87.487	.000	.513
Covariate	45.649	1	45.649	.268	.606	.003
group	8122.577	1	8122.577	47.678	.000	.365
Error	14140.109	83	170.363			
Total	281281.000	86				
Corrected Total	22339.593	85				
a. R Squared = .367 (Adjusted R Squared = .352)						

Table 7 indicates the Analysis of Covariance (ANCOVA) result on the significant difference in the posttest achievement mean score of students exposed to problem-based learning approach and those not exposed. The table shows that $F(1,83) = 47.68$, $p < 0.05$, since the p-value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of problem-based learning approach on the achievement of students in stoichiometry. The result further reveals an adjusted R squared value of .352 which means that 35.2 percent of the variation in the dependent variable which is achievement in stoichiometry is explained by variation in the treatment of problem-based learning approach, while the remaining is due to other factors not included in this study. This implies that problem-based learning approach can help improve students' achievement in stoichiometry.

Hypothesis Four: There is no significant difference between the posttest achievement mean scores of male and female students in the experimental group.

Table 8: ANCOVA Result on Effect of Treatment on Male and Female Students Achievement in the Experimental Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1013.068[a]	2	506.534	1.770	.184	.085
Intercept	8984.517	1	8984.517	31.392	.000	.452
Covariate	4.745	1	4.745	.017	.898	.000
Gender	1008.995	1	1008.995	3.525	.068	.085
Error	10875.712	38	286.203			
Total	185504.000	41				
Corrected Total	11888.780	40				

a. R Squared = .085 (Adjusted R Squared = .037)

Analysis of Covariance (ANCOVA) was conducted to determine if there is a significant effect of treatment on male and female students' achievement when taught stoichiometry using problem-based learning approach. Table 8 shows that the main effect of treatment on gender yielded $F(1,38) = 3.53$, $p > 0.05$, since the p value

of 0.068 is greater than 0.05 level of significance, the null hypothesis was retained, indicating that there was no significant effect of treatment on gender of students' when taught using problem-based learning approach. The result further reveals an adjusted R squared value of .037 which means that 3.7 percent of the variation in the dependent variable which is achievement in stoichiometry is explained by variation in the gender, while the remaining is due to treatment and other factors not included in this study. It means that problem-based learning approach can help improve achievement of both male and female students in stoichiometry.

DISCUSSION

The result on attitude of students towards stoichiometry indicated that majority of students in the experimental group had positive attitude towards stoichiometry in the posttest as against the control group where majority of the students still had negative attitude towards the subject. It is an indication that problem-based learning approach can change students' attitude to stoichiometry. The finding here corroborates Chileya and Shumba's (2020) position who, in a study on the impact of problem-based learning on learners' academic achievement in chromatography and science learning activation found that learners in the experimental group showed that PBL resulted in a positive impact on learners' academic achievement as well as science learning activation. A study by Sundas Majeed, S., Tayyaba, M., Haider, Z. and Raza, S. (2024) yielded similar results when the impact that learning through problem-solving has on secondary students' academic performance and metacognition in chemistry was examined. This study shows that students' academic performance and metacognition in secondary-level chemistry are more significantly impacted by the use of learning for the solution of various problems.

The result also revealed that problem-based learning approach is effective in improving and changing students' attitude across gender groups. It further revealed that there is no significant difference between male and female students' attitude, towards stoichiometry. The finding agrees with earlier findings of Taiwo and Ajagbe (2016) who investigated the attitudes of secondary school students towards science subjects and found that a higher proportion of the students display positive attitude towards science and that there was no significant difference between the attitude of male and female students towards science. The finding is also in tandem with that of Argaw, Haile, and Ayalew (2017), who did not find any gender difference in motivation and attitude to learn physics across groups when students were taught in the experimental class with PBL. Gender and type of school did not show any effect of changing attitude. However, the finding is contrary to that of Mbonyiryivuze, Yadav, and Amadalo (2021), who found a statistically relevant gender gap in favor of female when students were taught physics using PBL.

Problem-based learning approach was found to be effective in improving the achievement of students in stoichiometry as indicated in the result that those who were taught using problem-based learning approach achieved better than those in the control group who did not receive treatment. It further showed that there is significant difference between the posttest achievements of students in stoichiometry in the experimental and control group. This investigation is a clear indication of the usefulness of problem-based learning approach in promoting students' learning. This finding agrees with that of Aidoo, Boateng, Kissi and Ofori (2016) who found out that a significant difference occurred in the achievement of students exposed to PBL and those exposed to traditional instructional approach of teaching in chemistry. The finding is also in agreement with those of Chileya and Shumba (2020) and Gunter and Alpat (2017), who in their different studies involving chemistry concepts, found out that there was a statistically significant different between the scores of students taught using PBL and those thought in the control. They concluded that students in the experimental group were better able to understand the topics compared to the students in the control group.

The result also revealed that problem-based learning approach is effective in improving students' achievement across gender groups. It further revealed that there is no significant difference between male and female students' achievement in stoichiometry. This means that problem-based learning approach can help improve achievement of both male and female students in stoichiometry. The result is in agreement with the findings of Olo, Abonyi, Okafor and Omebe (2015) who reported no significant interaction effect of between teaching method and gender on the mean achievement scores of students taught Algebra using PBL instructional approach. The finding is however, contrary to that of Onyi, Njoku and Nwafor (2022), who carried a study on the efficacy of problem-based learning in promoting high achievement of students in chemistry. They found

that gender had a significant influence on students' academic achievement in electrochemistry in favor of the male students even though the interaction effect of teaching method and gender was not significant. It also differs from the findings of Ajai and Imoko (2015) who, in a study on gender differences in mathematics achievement and retention scores found that female students outperformed their male counterparts.

CONCLUSION

The study was on improving students' attitude and achievement in stoichiometry using problem-based learning approach in Jos, Plateau State. It was concluded that the use of problem-based learning approach promotes students' achievement in the classrooms. The result of the study showed that the attitude and achievement level of both experimental and control groups of students before treatments were negative and low and there was no significant difference in students' attitude and achievement in stoichiometry. The result further showed that students taught using problem-based learning approach had a more positive attitude and performed significantly better than their counterparts taught with conventional lecture approach. Similar results were obtained by Charif (2010) who found out that implementing the problem-based learning approach improved students' achievement and attitude in chemistry. The results of a study by Kissi (2016) also showed that PBL is an effective way for to teach chemistry so as to improve students' critical thinking and problem-solving skills. With similar results like those of Shehu (2015), it can be said that problem-based method can applied for the teaching of chemistry as a

subject, seeing that its use improved achievement, attitude and critical thinking and covering a wide range of concepts. The problem of poor achievement can be reduced by the use of PBL instructional model instead of the conventional (lecture) method. Students' achievement depends on their participation in the teaching learning process not gender as revealed by the study as PBL instructional approach provided equal opportunities in the learning process for male and female students to benefit maximally when taught stoichiometry using problem-based learning approach.

RECOMMENDATIONS

In view of the findings of this study, the following recommendations are made. This study recommends that teachers implement problem-based learning in teaching science concepts especially chemistry for middle school students. Chemistry teachers should adopt the use of PBL instructional approach since it has been found to be effective in enhancing students' achievement compared to traditional method in order to provide and direct the proper understanding of Chemistry concepts by students. Government and school proprietors should encourage the training and re-training of Chemistry teachers through series of workshops, seminars and symposium on how to incorporate effectively problem-based learning approach during lessons since it has been found efficacious in classroom instructions.

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