

**EFFECTS OF PROBLEM-BASED LEARNING STRATEGY ON SENIOR SECONDARY TWO STUDENTS' ATTITUDE TOWARDS 'MOLE' CONCEPT CHEMISTRY IN JOS NORTH, PLATEAU STATE, NIGERIA**

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**ABSTRACT**

*The study determined the effect of problem-based learning strategy on chemistry students' attitude towards 'mole concept' in Jos North Area of Plateau State, Nigeria. Two research questions were answered and two hypotheses tested at 0.05 level of significance. Quasi-experimental pre-test and post-test design was employed for the study. A total of 77 SSII Chemistry students out of 1,570 drawn from 22 public senior secondary schools were selected through random sampling technique as the sample for the study. The instrument utilized for the study was the Mole Concept Attitude Scale (MCAS), developed by the researcher and was validated by three experts, one from Chemistry Education unit, one from Test and Measurement unit and one chemistry teacher. The reliability coefficient of the instrument was established using 20 SSII Chemistry students from a different secondary school that was not part of the study. Cronbach's Alpha reliability estimate was used to determine the internal consistency of the items of MCAS respectively, which was found to be 0.79. The data collected were analyzed using mean, standard deviation and ANCOVA. The study found that students in the experimental group achieved significantly higher mean attitude scores than students in the control group. There was significant difference in mean attitude scores of male and female students who were exposed to PBL strategy in favour of male students. Based on these findings, the study recommended among others, that Chemistry teachers should be encouraged to utilize PBL strategy as a means of instruction since it improves students' attitudes in mole concept chemistry.*

**Key words: Attitude    Effects    Mole concept    Problem-based learning strategy**

**INTRODUCTION**

Chemistry, known as the "central science," explores the composition, structure, properties, and changes of matter. It plays a key role in understanding the natural world by connecting the microscopic world of atoms and molecules to the macroscopic world we can observe. Through the application of chemical principles, scientists have uncovered the mechanisms behind biological processes, environmental interactions, and material behavior, leading to innovations in various fields. This knowledge not only deepens our understanding of nature but also drives technological advancements and solutions across industries. Chemistry's influence goes beyond laboratories, impacting industries such as pharmaceuticals, agriculture, and manufacturing. It is essential for synthesizing drugs, developing fertilizers and pesticides, and creating new materials with enhanced properties. Technological advancements, from electronics to renewable energy, rely heavily on chemistry. In medicine, understanding biochemical processes has led to life-saving treatments. Chemistry is fundamental to everyday life, from the food we eat to the products we use, and is crucial for shaping modern society.

For a nation to advance, chemistry is crucial in driving scientific and technological development, which directly affects the well-being of its citizens. Countries committed to science often experience economic growth. The importance of chemistry is widely recognized in education as well, where it is seen as a key subject for advancing scientific and technological progress (Zudonu,

2018). Despite its importance, student performance in chemistry, particularly in senior secondary examinations, has been unsatisfactory. Reports from the West African Examination Council (WAEC) from 2012 to 2022 highlight difficulties students face in understanding key concepts like the mole concept, chemical equilibrium, stoichiometry, and others. Many students find chemistry difficult, which has been documented in several studies (Musonda, 2014; Fahd, Noreen & Anosha, 2022). Wang et al. (2021) suggest that students struggle with chemistry because they do not see its relevance to everyday life or believe their intelligence is fixed.

One challenging concept is the mole, which represents an amount of a substance ( $6.022 \times 10^{23}$  entities, Avogadro's number). This concept is vital for chemists to express quantities of atoms, molecules, or ions practically. The mole concept, which involves working with large numbers and ratios, is intimidating for many students (Shehu, 2015). It is a fundamental part of problem-solving in chemistry, relating to molar mass, Avogadro's constant, and other key topics (Petrucci et al., 2017).

A student's attitude plays a crucial role in understanding the mole concept. Attitudes, which encompass emotions, beliefs, and behaviours, can either enhance or hinder a student's learning process. Students with a positive attitude, who approach the subject with curiosity and openness, tend to perform better, while those with a negative attitude may struggle (Perloff, 2016; Montes et al., 2018). Teachers are essential in fostering positive attitudes, as student achievement often aligns with their attitude towards the subject (Al-Mutawah & Fateel, 2018; Montes et al., 2018).

Research has shown that positive attitudes lead to higher academic achievement, while negative attitudes correlate with lower success (Marcela & Mala, 2016; Hacıeminoglu, 2016). However, poor teaching methods also contribute to low student performance. Teachers should adopt instructional strategies that engage students and promote a positive learning environment. One vital teaching approach is problem-based learning (PBL), which emphasizes solving real-world problems as the core of the learning process. PBL promotes critical thinking and self-directed learning by challenging students to apply their knowledge to solve complex problems (Hallinger & Bridges, 2016). This method not only deepens understanding but also builds essential skills for future success (Amalia, Surya, & Syahputra, 2017). In PBL, students take an active role in their learning, moving away from passive information receivers to problem solvers (Yaayin, 2018).

Studies have shown that PBL improves students' attitudes towards courses, leading to better outcomes (Demirel & Dagyar, 2016). Its success depends on the positive attitudes of both students and teachers (Treesirichod et al., 2018). In the context of teaching the mole concept, PBL could make this abstract idea more understandable and engaging for students, aligning with current educational trends focused on developing both knowledge and skills. Gender differences in attitudes towards chemistry have also been debated. Some studies suggest that gender affects attitudes, while others find no significant differences (Heng & Karpudewan, 2014; Wahyudiati et al., 2020). Regardless, nurturing positive attitudes towards chemistry is essential for all students to achieve success in the subject.

### **OBJECTIVES OF THE STUDY**

The study sought to achieve the following to:

1. determine the effect of problem-based learning strategy on attitude of SSII chemistry students towards the Mole Concept.
2. determine the difference in the attitude of male and female SSII students when taught chemistry using PBL strategy

### **RESEARCH QUESTIONS**

The study will be guided by the following questions;

1. What is the effect of problem-based learning strategy on attitude of SSII chemistry students towards the Mole Concept?

2. What is the difference in the attitude of male and female SS II students taught chemistry using PBL Strategy?

**HYPOTHESES**

1. There is no significant difference in the post-test attitude mean score of students taught mole concept using problem-based learning strategy and lecture method
2. There is no significant difference in the post-test attitude mean score of female and male students taught mole concept using PBL strategy

**METHOD**

Quasi-experimental research design was used for the study. Specifically, the nonrandomized control group, pre-test - post-test design was used. Levy and Ellis (2011) posit that the quasi-experimental design is a type of experimental design in which the researcher has limited leverage and control over the selection of samples. The researcher adopted quasi-experimental design because there was no randomization of subjects to experimental groups, rather intact classes were used. The population for the study consisted of Senior Secondary two (SSII) chemistry, students, drawn from 22 public co-educational schools in Jos North Area Council (JNAC), Plateau State, Nigeria. The sample was made up of two schools. One school was selected for the experimental group while the other for the control group. The total number of students involved in this research from the two schools is 77. Simple Random sampling technique was used. The researcher developed Mole Concept Attitude Scale (MCAS) for data collection. MCAS consisted of 20 items, structured on a Likert-type scale for assessing students’ attitude. The data collected were analyzed using mean and standard for answering the research questions, while analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

**RESULTS**

**Research Question 1:** What is the effect of problem-based learning strategy on attitude of SSII chemistry students towards the Mole Concept?

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

Group	Pre-test		Post-test		Mean Gain	$\bar{x}$ - Difference
	N	Mean	SD	Mean		
Experimental	45	49.54	8.48	78.52	9.44	21.38
Control	32	46.37	11.14	53.97	8.81	

Table 1 presents the pre-test and post-test mean attitude mean scores of Chemistry students in both the experimental and control groups. At the pre-test stage, the experimental group had a mean score of 49.54 with a standard deviation of 8.48, while the control group had a slightly higher mean score of 46.37 and a standard deviation of 11.14. After the instructional intervention, the post-test results revealed a significant change in attitude. The experimental group, which received treatment using problem-based learning strategy achieved a considerably higher post-test mean score of 78.52 with a standard deviation of 9.44, while the control group, which did not receive any such treatment, had a lower post-test mean score of 53.97 with a standard deviation of 8.81. These results indicate a clear increase in student attitudes towards Chemistry after the treatment, particularly among those in the experimental group. The mean gain difference between the post-test scores of the two groups was 21.38 in favour of the experimental group, demonstrating the greater effectiveness of the problem-based learning strategy in positively influencing students’ attitudes.

**Research Question 2:** What is the difference in the attitude of male and female SS II students taught chemistry using PBL Strategy?

**Table 2: Male and female Students' Attitude Mean Scores in Chemistry Taught Using PBL Strategy**

Group	Gender	Post-test			$\bar{x}$ - Difference
		N	Mean	SD	
Experimental	Male	20	88.77	8.32	20.51
	Female	25	68.26	7.43	

Table 2 provides an analysis of the post-test attitude scores of both male and female students in the experimental group. The male students had a relatively high mean attitude score of 88.77 with a standard deviation of 8.32. In contrast, the female students, who were exposed to the Problem-Based Learning strategy, achieved a lower mean attitude score of 68.26, with a standard deviation of 7.43. This notable difference between the male and female students is reflected in the mean score disparity of 20.51 points in favour of the male students. The findings from the table indicate that male students developed a significantly more positive attitude toward the mole concept compared to the female students.

**Hypothesis One:** There is no significant difference in the post-test attitude of students taught mole concept using problem-based learning strategy and lecture method.

**Table 3: Analysis of Covariance (ANCOVA) of the Post-test Achievement Mean Score of Students in Experimental and Control Groups**

Source	Type III of squares	Sum df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2175.712 <sup>a</sup>	4	527.38	5.966	.00	.252
Intercept	13627.31	1	13123.34	147.617	.00	.677
Group	1730.112	1	1731.132	19.163	.00	.002
Experimental group*	16.069	1	14.179	.158	.00	
Error	6313.963	42	91.438			
Total	427672	46				
Corrected Total	8469.684	43				

Table 3 presents the results, indicating that the group taught with the PBL strategy achieved a statistically significant F-ratio of 19.163, with a p-value of 0.00. Since this p-value is below the 0.05 threshold set as the level of significance, the null hypothesis—stating that there is no significant difference in post-test attitude between students taught using the PBL strategy and those taught using the lecture method—is rejected. Therefore, the conclusion drawn is that there is a significant difference in the post-test attitude of students, with those taught using the PBL strategy showing a greater positive shift in attitude toward the mole concept than those taught using the Lecture method.

**Hypothesis Two:** There is no significant difference in the post-test attitude mean score of female and male students taught mole concept using PBL strategy.

**Table 4: Analysis of Covariance (ANCOVA) of the Attitude Mean Scores of Male and Female Students in Experimental and Control Group**

Source	Type iii of squares Corrected	Sum df	Mean Square	F		Partial Eta Squared
Model	2324.242 <sup>a</sup>	4	516.23	5.912	.00	.242
Intercept	13674.34	1	12658.34	137.612	.00	.412
Gender	12.451	1	11.254	.137	.712	.002
Experimental group*	16.061	1	16.179	.178	.00	
Error	6423.863	42	94.248			
Total	414442	46				
Corrected	8179.184	43				

The results presented in Table 4 show that the ANCOVA yielded an F-ratio of 0.178, with an associated p-value of 0.00 and a low effect size (partial eta squared = .002). Since the p-value is less than the 0.05 level of significance, the null hypothesis—which posited no significant difference in the post-test attitude mean scores between male and female students—was rejected. Therefore, it can be inferred that there is a statistically significant difference in the post-test attitude mean scores between male and female students taught the mole concept using the PBL strategy. This result underscores the presence of gender-based differences in attitudes towards the mole concept when taught using the PBL approach.

## DISCUSSION

Regarding students' attitudes towards chemistry, the findings showed that the experimental group had a higher post-test attitude mean score (78.52) compared to the control group (53.97), resulting in a mean difference of 21.38. The significant difference in post-test attitudes suggests that PBL not only improves academic achievement but also positively influences students' attitudes toward learning, particularly when dealing with complex scientific concepts like the mole concept. By involving students in real-world problem-solving, PBL likely made the subject matter more relevant and engaging, thereby improving students' attitudes. This outcome confirms the findings of Festus and Ekpete (2012), Kadir et al. (2016), and Alper et al. (2014), who found that students treated with PBL developed better attitudes toward learning than those taught using traditional lecture methods. However, some studies, such as those by Özdil (2011) and Reynolds & Hancock (2010), have suggested that PBL has either a negative or neutral effect on student attitudes. Similarly, Batdı (2014) and Demirel and Dagyar (2016) reported only a medium effect of PBL on students' attitudes towards courses.

In terms of attitude, male students in the experimental group demonstrated a significantly higher mean attitude score (88.77) compared to female students (68.26), with a mean gain difference of 20.51 points. While PBL effectively fostered positive attitudes toward the mole concept among male students, it was less impactful for female students. This finding aligns with the research of Yusa and Ikhtan (2021), who reported significant gender differences in attitudes towards chemistry, though in their study, female students exhibited better attitudes than males. The current results suggest that, in this context, male students may have responded more positively to PBL, possibly due to the active, problem-solving nature of the teaching strategy. According to Seba,

Ndunguru and Mkoma (2013), whose study indicated a difference between boys and girls' attitudes toward chemistry in the level of anxiety, enjoyment, and confidence, Male students were found to have more confidence, excellent performance, and enjoyment in physics and chemistry than their female counterparts. As a result, boys have more positive attitudes toward chemistry and physics than girls, and they tend to participate more in chemistry and physics activities than female students.

### CONCLUSION AND RECOMMENDATIONS

In conclusion, the study demonstrated that problem-based learning (PBL) strategy was significantly more effective than traditional lecture method in improving students' attitudes towards chemistry, specifically in mastering the mole concept. The experimental group, taught using PBL, showed a greater mean gain in attitude compared to the control group, underscoring the interactive and student-centered advantages of PBL. While both male and female students benefited from PBL, the findings revealed a slight gender disparity, with male students outperforming their female counterparts in attitude measures. Based on these findings, the following recommendations are made:

1. Teachers should receive training in implementing PBL effectively, focusing on how to facilitate active learning, critical thinking, and real-world problem-solving.
2. Given the demonstrated effectiveness of PBL in improving both academic achievement and student attitudes, educators and curriculum developers should consider incorporating PBL strategies more broadly in chemistry education, particularly for complex topics like the mole concept.
3. Since PBL has shown positive results in chemistry, its application should be explored in other scientific disciplines to determine whether similar improvements in achievement and attitudes can be replicated.

### REFERENCES

- Al-Mutawah, M. A., & Fateel, M. J. (2018). Students' achievement in math and science: How grit and attitudes influence? *International Education Studies*, *11*(2), 97-105. <https://doi.org/10.5539/ies.v11n2p97>
- Alper, A., Öztürk, S., & Akyol Aydın, C. (2014). Problem-based learning studies in Turkey. *Ankara University Journal of Faculty of Educational Sciences*, *47*(1), 397-422. Retrieved from <http://dergiler.ankara.edu.tr/dergiler/40/1917/20127.pdf>
- Amalia, E., Surya, E., & Syahputra, E. (2017). The effectiveness of using problem-based learning (PBL) in mathematics problem solving ability for junior high school students. *International Journal of Advance Research and Innovative Ideas in Education*, *3*(2), 2-6.
- Batdı, V. (2014). The effects of a problem-based learning approach on students' attitude levels: A meta-analysis. *Educational Research and Reviews*, *9*(9), 276-279. <https://doi.org/10.5897/ERR2014.1771>
- Demirel, M., & Dağyar, M. (2016). Effects of problem-based learning on attitude: A meta-analysis study. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(8), 2111-2130.
- Festus, C., & Ekpete, O. A. (2012). Improving students' performance and attitude towards chemistry through problem-based-solving techniques (PBST). *International Journal of Academic Research in Progressive Education and Development*, *1*(1), 167-174.

- Hallinger, P., & Bridges, E. M. (2016). A systematic review of research on the use of problem-based learning in the preparation and development of school leaders. *Educational Administration Quarterly*, 53(2), 1-34.
- Hanefar, M. S., Hussain, T. M. A., & Jarvis, A. (2021). The effect of problem-based learning on students' learning attitude in tertiary level education: A case study of the college system in Bangladesh. *Journal of University Teaching & Learning Practice*, 18(4). <https://doi.org/10.53761/1.18.4.17>
- Heng, C. K., & Karpudewan, M. (2015). The interaction effects of gender and grade level on secondary school students' attitude towards learning chemistry. *Eurasia Journal of Mathematics, Science & Technology Education*, 4(11), 889-898
- Kadir, Z. A., Abdullah, N. H., Anthony, E., Salleh, B. M., & Kamarulzaman, R. (2016). Does Problem-Based Learning Improve Problem-Solving Skills? — A study among business undergraduates at Malaysian premier technical university. *International Education Studies*, 9(5), 166-172.
- Montes, L. H., Ferreira, R. A., & Rodríguez, C. (2018). Explaining secondary school students' attitudes towards chemistry in Chile. *Chemistry Education Research and Practice*, 19(2), 533-542.
- Reynolds, J. M., & Hancock, D. R. (2010). Problem-based learning in a higher education environmental biotechnology course. *Innovations in Education and Teaching International*, 47(2), 175-186. <https://doi.org/10.1080/14703291003718919>
- Seba, J. M., Ndunguru, P. A., & Mkoma, S. L. (2013). Secondary school students' attitudes towards chemistry and physics subjects in Tarime Mara, Tanzania. *Research Article*, 4(2), 642-647.
- Shehu, G. (2015). The effect of problem-solving instructional strategies on students' learning outcomes in senior secondary school chemistry. *IOSR Journal of Research and Method in Education (IOSR-JRME)*, 5(1), 10-14.
- Wahyudiati, D., Rohaeti, E., Irwanto, A., Wiyarsi, A., & Sumardi, L. (2020). Attitude towards chemistry, self-efficacy, and learning experiences of pre-service chemistry teachers: Grade level and gender differences. *International Journal of Instruction*, 13(1), 234-254.
- Yaayin, B. (2018). The effectiveness of problem-based learning approach to mole concept among students of Tamale College of Education. *Africa Development and Resources Research Institute Journal*, 27(8)(4), 18-37.
- Zudonu, O. C. (2018). Teachers' utilization of research findings on chemistry teaching methods in secondary schools in Rivers State, Nigeria. (Unpublished Ph.D. thesis). University of Nigeria, Nsukka.