Jurnal Pembelajaran Sains
VOLUME 9 NOMOR 1, JUNE 2025

http://journal2.um.ac.id/index.php/
ISSN: 2527-9157

PROBLEM BASED LEARNING IMPACT: ENHANCING CHEMISTRY LEARNING OUTCOMES

Talitha Emilia[1], Fadia Hayya Tahta Auniillah[2*], Setia Rahmawan[3]
[1, 2, 3] Department of Chemistry Education, Faculty of Tarbiyah and Education, Sunan Kalijaga State Islamic University, Yogyakarta, Indonesia

Email*: fadiaa.aunillah@gmail.com

Abstract
This study aims to examine and describe using the problem-based learning (PBL) learning model as a strategy to improve chemistry learning outcomes. This qualitative research uses the literature review method, which involves searching for previously published writings to find theoretical references related to the case or issue. The secondary data analysis method uses data on student learning outcomes in chemistry courses with a quantitative descriptive approach. Documentation, or browsing textual sources with various themes and issues, is used to collect data. Some data sources are books, online journals, the internet, conferences, research findings, and information related to study materials. The results of this literature study research show that using the problem-based learning model can improve students's learning outcomes; this is demonstrated by the lowest score of 31.11% in the first cycle and the best score of 100% in the second cycle.

Keywords: *Problem-Based Learning, Student Learning Outcomes, Chemistry Learning, Literature Review*

Received: 12 January 2025 | Revised: 12 March 2025 | Published: 28 June 2025

INTRODUCTION

Using problem-based learning (PBL), students try to develop meaningful answers to contextual challenges in the real world that are not rigidly organized (Rhem, 1998). Students are given real-world problems to overcome using their knowledge in a teaching method called "problem-based learning" (Asriningtyas et al., 2018). With PBL, students are first given problems to debate and work on as a group to help them apply their understanding of the idea. The problem is tailored to various demands and ideas (Ariandi, 2017). Students participate in problem-solving and other assignment-delivery activities through the PBL learning model, allowing students to work on building their knowledge to produce authentic products. Building learning is done by using problems as a reference and focusing on learning activities related to a discipline's essential ideas and principles (Waras, 2008). To encourage students to learn, the problem-based learning approach introduces contextual challenges (Jayadiningrat & Ati, 2018).

Because problem-based learning poses difficulties at the beginning of the learning process, it helps students assimilate and apply new information to optimize science learning performance. Because of learning, in this case, student-centered learning, the instructor facilitates the learning process (Kristiana & Radia, 2021). A practical inquiry-based learning approach is the problem-basedlearning model, in which students work on learning tasks involving real-world problems as a basis for conducting more in-depth research regarding the knowledge and skills they need to acquire (Yulianti & Gunawan, 2019). Previous research has shown that learning activities emphasize the presentation of real-world problems to students in subjects where learning materials relate to everyday issues. Students must work through investigative activities to solve these difficulties, improve their creative thinking skills, and gain knowledge and critical concepts from problem-based learning (PBL) (Alamiah & Afriansyah, 2017).

Because chemistry encompasses abstract and complex ideas, students may believe studying chemistry is challenging (Zakiyah et al., 2018). Students find chemistry lessons on acid-base materials, which combine abstract and quantitative theoretical concepts, especially the idea of developing acid-base and calculating the pH value of acid-base, very challenging to understand. Students will not be able to understand the basic principles of chemistry without an abstract understanding of chemistry (Addiin & Redjeki, 2014). One of the most challenging materials for students is acids and bases. This material is considered difficult because it covers a wide range of topics and requires mastery of introductory material, including the characteristics of material particles, the composition and properties of solutions, atomic structure, ionic and covalent interactions, reaction equations, ionization, and equilibrium (Indrayani, 2013). As a result, students who have difficulty understanding this idea will have problems in the later learning process (Ristiyani & Bahriah, 2016).

The achievements that students have after receiving instruction are known as learning outcomes. In the learning process, learning outcomes are very decisive. Teachers can find out the progress of their students in the learning process by conducting assessments based on learning outcomes (Suriyanto et al., 2020). Classification of Bloom learning outcomes (Mahmudi et al., 2022) Divide them into three categories that must be considered in all teaching and learning activities. The three areas of focus are psychomotor, affective, and cognitive. Learning objectives related to intelligence, memory, and knowledge fall within the mental domain. Learning objectives related to attitudes, values, feelings, and interests fall within the emotional realm. Learning objectives related to motor or physical skills supported by psychic talents fall within the psychomotor realm. Six skill levels identified by (Yeni et al., 2022) as follows: (1) reflex movements, also called involuntary movements; (2) basic movement skills; (3) the ability of perception to distinguish auditory and motor stimuli; (4) physical abilities (strength, harmony, and precision); (5) movement skills ranging from simple to complex; and (6) abilities related to expressive and interpretive motor communication. Several factors, including individual skills, classroom environment, teacher quality, and student learning characteristics, can influence how students learn healthily (Rosyidah, 2016). Many students have difficulty understanding the concept of chemistry in depth due to the passive learning approach, which leads to low engagement and suboptimal learning outcomes. Although various active learning methods have been explored, research specifically examining the effectiveness of PBL in high school chemistry is still limited. PBL was chosen because it bridges this gap by introducing problem-based learning that enhances conceptual understanding and fosters critical thinking and scientific skills that are essential for the modern era.

This literature study aims to synthesize existing research to confirm the efficacy of the Problem-Based Learning (PBL) paradigm in improving student learning outcomes in high school chemistry courses, especially identifying cognitive, emotional, and psychomotor benefits related to its application. This review provides a consolidated understanding of the impact of PBL on student engagement and learning, providing educators with evidence-based insights for effectively integrating PBL into the chemistry curriculum, thus fostering a scientific mindset and improving overall student performance.

METHODS

Classroom action research is this kind of research. Classroom action research focuses on finding solutions to problems that arise in the classroom to solve problems or make changes (Latief, 2016). The teaching methods and quality provided in the school can be improved by applying action research in classrooms experiencing difficulties (Nurgiansah et al., 2021). This research aims to enhance students' learning achievement by improving teaching methods and their understanding of acid-base materials. The information used in this study is secondary. Data collected through reading, seeing, or listening without having to make direct observations is called secondary data. Secondary data sources come from reputable books and journals supported by unreputable journals. The data collection technique was searching for articles published in online journals through Google Scholar related to chemical misconceptions about acids and bases (Zulkhairi, 2022). The keywords used to search for articles are: "Classroom action research," "Acidic base," "Problem-based learning (PBL)," "Learning outcomes". The articles have been analyzed to obtain information on chemical issues related to acids and bases.

This literature research analyzes articles by reviewing, summarizing, and analyzing data from previous research (Pancaningrum, 2021). A Literature study is research conducted by reviewing and analyzing the results of previous research on official websites, campus publication media, or scientific publication media (Panggabean et al., 2021). The stages of this research are carried out: (1) Search for literature that is by the research topic, such as related keywords and the full text of the article; (2) Conduct a review by reading literature; review is carried out by reading abstracts, and keywords; (3) Collect data; (4) Analyze articles that meet the inclusion criteria (which represent the research subject) (Handayani & Koeswanti, 2021; Rahayu & Fitriza, 2021). The researcher selected ten journals relevant to this topic because of the limited time that prevented them from reviewing more literature. By focusing only on the most important sources, this research can be carried out more efficiently.

RESULT AND DISCUSSION

According to the search results, the authors found ten publications published between 2018 and 2023 relevant to the research subject. After conducting the analysis, the results of the study are arranged in the following Table 1 groups:

Table 1. Article Data

Data Collection Criteria	Data Clustering	Number of Articles Taken
Year of Publication	2018	1
	2019	2
	2020	3
	2021	1
	2022	1
	2023	2
Types of Learning Models	Problem-Based Learning	10
Dependent variables	Learning outcomes	10

Article data processing is carried out by summarizing and determining the percentage value of improvement based on the skills acquired by students in cycle I and cycle II based on information presented in qualitative and quantitative descriptive formats. Table 2 below, concludes from the data analysis of the application of PBL on acid-base materials to improve student learning outcomes.

Table 2. Data collected from observations on how PBL Learning approaches improve student learning outcomes

No.	Author's name	Article Title	Research methods	Completeness		Increased
				Cycle I	Cycle II	
1.	Esti Widyarsih	Implementation of the Problem-Based Learning Model in Improving Student Learning Outcomes in Acid Basa Solution Material	Classroom action research	55.2%	72.5%	35%
2.	I Pande Putu Alit Antara	Problem-Based Learning Model to Improve Chemistry Learning Outcomes on the Subject of Thermochemistry	PTK, data collection techniques using learning outcome tests	88,57%	100%	11,43%
3.	Heni Susanty	Application of Post-Pandemic Problem-Based Learning (PBL) to Improve Learning Outcomes of Acid-Base	PTK, observation of the processing of PBL learning methods,	69%	92%	23%

		Chemistry for XI Science 3 MAN Kapuas Students for the 2022/2023 Academic Year (Application of Post-Pandemic Problem-Based Learning (PBL) to Improve Acid-Base Chemistry Learning Outcomes for XI Science 3 MAN Kapuas Students for the 2022/2023 Academic Year)	observation of student and teacher activities, and formative tests			
4.	Gusti Ayu Suarsani	Improving Chemistry Learning Outcomes with Elemental Chemistry Subject Matter Through the Application of Problem-Based Learning Model	PTK, observation data collection techniques, documentation tests, interviews	77,63%	79,6%	1,97%
5.	Fauzi Derita Saputri, Sri Yamtinah, and Endang Susilowati	Application of LKS-Assisted Project Based Learning Learning Model on Acid-Base Materials to Improve Learning Activities and Achievement of Grade XI Students of SMA Batik 2 Surakarta Academic Year 2018/2019 (Application of LKS-Assisted Project-Based Learning Model on Acid-Base Materials to Improve Classroom Learning Activities and Achievements)	PTK, qualitative aspects in the form of data from interviews, observations, document studies or archives. The quantitative aspect is in the form of an assessment of learning activities and student achievements in acidic and alkaline materials.	72,96%	81,92%	8,96%
6.	Herlina	Application of Problem-Based Learning to Improve Chemistry Learning Results on Hydrocarbon Materials	PTK, observation, test	60%	92%	32%
7.	Hikmia at risk, Frensi	The Effect of Model-Based Learning with Audio Visual Media and	PTK, experiment	31,11%	83,94%	52,83%

	Hasanah, Ani Sutiani	Real Laboratory Acid-Base Material on Learning Outcomes				
8.	Cut Meutia	Improving Students' Learning Outcomes and Critical Thinking Skills in Chemical Calculation Materials Through Problem-Based Learning Models	PTK, test data collection techniques, observation	57,79%	75,24%	17,45%
9.	Sumiati	Increasing Motivation and Learning Outcomes in Chemistry Learning Through the Application of the Problem-Based Learning (PBL) Learning Model (Increasing motivation and learning outcomes in chemistry learning through the application of the Problem-Based Learning (PBL) learning model)	PTK, data collection techniques using triangulation, inductive data analysis, and research results emphasize meaning.	76,5%	94,1%	17,6%
10.	Ahaky Roza Clorawati, Krisna Dewi, Hermansyah Amir	Application of Problem-Based Learning Model in Improving Motivation and Learning Outcomes of Chemistry Students (Application of Problem-Based Learning Model in Improving Motivation and Learning Outcomes of Chemistry Students)	PTK, questionnaire data collection techniques, and learning outcome tests	66%	94,11%	28,11%
Average effect of the application of the PBL model on chemistry learning				65,47%	86,54%	22,83%

The data in observation table 2 shows that the lowest score is 31.11% in cycle I, and the best score is 100% in cycle II. This shows how using a learning model can improve the completeness of student learning outcomes regarding of chemical balance content. The significant increase in scores in cycles I and II shows the use of learning models to improve the completeness of learning outcomes.

After reviewing several related studies, the researcher conducted Classroom Action Research (PTK) to determine the impact of the application of the PBL paradigm on improving chemistry learning outcomes. The Kemmis and McTaggart or John Elliot models are used in their implementation. It has four research steps: planning, executing, observing, and meditating. This process is carried out several times. In the end, the instructor showed that student learning outcomes can be improved through the PBL learning model on chemistry after conducting the research stages and analyzing the data by comparing the research results in each cycle.

Results of two cycles of action of classroom action research (PTK) (Widyarsih, 2020) with the title Implementation of Problem-Based Learning Models in Improving Student Learning Outcomes on Acid-Base

Solution Materials stated that in the Acid-Base Solution class, it can be improved through the use of PBL. The average score increased from 55.2 in the pre-action to 72.7 in the first cycle, indicating an increase in student learning outcomes by 35%. In cycle II, there was a significant increase in student learning outcomes, with an average score of 80.77 and an increase in learning outcomes of 35%. This illustrates improving students' chemistry learning outcomes when taught using the Problem-Based Learning (PBL) paradigm in the Acid and Base textbook in Class XI Science 2 MAN 1 Pangandaran. Using PBL techniques has improved student learning outcomes in the Acid and Base curriculum in class XI Science 2 MAN 1 Pangandaran.

Classroom action research is conducted (Antara, 2022) titled Problem-Based Learning Model to Improve Chemistry Learning Outcomes in Thermochemistry Subjects. Considering that the criteria for completing the learning of SMA Negeri 1 Semarapura students in the field of chemistry is 75, the initial results with an average score of 76.54 show that student's ability in this subject is still relatively low. According to the existing theory, if the PBL learning model is used correctly, the average learning skills of students in the first cycle can increase and reach an average of 80.77. Meanwhile, this average is not ideal because only thirty-one students scored higher than KKM. Meanwhile, the percentage of student learning completion reached 88.57%. Cycle II achieved an average score of 84.49 with 100% learning completeness. The experimental approach used in the PBL paradigm can facilitate learning and communication between teachers and students. In addition, the PBL approach can improve students' chemistry learning outcomes in thermochemistry subjects, including critical thinking skills, activity levels, creativity, and problem-solving skills.

Further research by (Susanty, 2023) in his scientific article entitled The Application of Post-Pandemic Problem-Based Learning (PBL) to Improve Chemistry Learning Outcomes of Acid-Base Materials for XI Science 3 MAN Kapuas Students for the 2022/2023 Academic Year. In the 2022–2023 academic year, MAN Kapuas conducted classroom action research on chemistry education. Science 3 students in class XI were used as research subjects, and in the sampling process complete sampling was used. Individual KKM score achievement indicators with a minimum completeness score of 70 and a classical completeness score of at least 85% were used in research on improving chemistry learning outcomes. The increase in learning completeness was obtained from 69% to 92% of the results of learning activities carried out during two cycles, both from observation and evaluation of learning activities using the PBL method. The stages of achievement of each indicator are carried out in two cycles. It can be concluded that the completeness of learning using PBL learning techniques in post-pandemic learning on classical acid-base chemistry material is 92%, with an average score. In addition, there was an increase in learning outcomes from an average score of 70.8 to 82.5. 82.5 has performed impressively.

Classroom action research is conducted (Suarsani, 2019) titled Improving Chemistry Learning Outcomes with Basic Materials on Elemental Chemistry Through the Application of a Problem-Based Learning Model. Class learning outcomes The findings of the first cycle showed that the average grade of students increased from the pre-cycle. The findings of the first cycle showed that the average student score was 77.63, the completion of learning was 73.33%, and the percentage of students who had not completed learning was 26.67%. Cycle II statistics show that the average student score is 79.6, the learning completion is 100%, and the student has demonstrated his or her talent to the fullest, resulting in 30 students who complete and improve their learning outcomes to reach their best ability. Researchers use the PBL learning approach, where students receive continuous support through conversation and self-paced problem-solving learning, to improve learning outcomes.

The following research was conducted by (Saputri et al., 2020) in their scientific article entitled Application of the LKS Problem-Based Learning Model on Acid-Base Materials to Improve Class Learning Activities and Outcomes, The research findings on the completeness of learning activities carried out in the classroom were shown by an increase in achievement from the first cycle of 69.12% to 77.84%. In the first cycle, there was an increase in learning completeness in the element of knowledge by 34.48%. In comparison, in cycle II, there was an increase in learning completeness in the element of knowledge by 75.86%. Meanwhile, the first cycle assessment of the achievement of the skill aspect was 81.83%, increasing to 87.52%, and the first cycle assessment of the attitude aspect was 75.86%, rising to 95.56%.

Furthermore, the research was conducted (Herlina, 2020) titled Application of Problem-Based Learning to Improve Chemistry Learning Outcomes on Hydrocarbon Materials. Classroom Action Research (CAR) is a methodology typically consisting of two (2) cycles. This research was conducted in the classroom.Classroom action research is generally carried out in two (2) cycles, each with four (4) stages: planning, implementation, observation, and reflection. The task of the first learning cycle is to translate the number of moles into the number of particles, mass, and volume of material. Meanwhile, the learning activities of the second cycle focus on limiting reagents, molecular formulas, and empirical formulas. In

cycles I and II, there was an increase in posttest results, the average percentage increased from 60% to 92%, from 69.47 to 78.53. This shows how the PBL approach can improve students' understanding of hydrocarbon content.

Further research was conducted by (Hikmi et al., 2019) in their scientific article entitled The Influence of Model-Based Learning with Audio Visual Media and Real Laboratory Acid-Base Materials on Learning Outcomes. The study revealed the difference in improving student learning outcomes between implementing PBL and other approaches. The model is applied with audiovisual materials, and when PBL is used in a real laboratory with Acid-Base materials, where the learning outcomes of students obtained from the use of the PBL model with audiovisual materials are more significant than the learning outcomes of students obtained from the use of the PBL model with the actual laboratory. For students who followed the PBL-based teaching approach with audiovisual materials, an average score of 31.11 was obtained in the first test, while 83.94 was obtained in the last.

Classroom action research is conducted by (Meutia, 2021), titled Improving Students' Learning Outcomes and Critical Thinking Skills in Chemical Calculation Materials Through a Problem-Based Learning Model. This study aims to determine how the PBL learning paradigm choice class is based on its ability to involve students in the learning process directly. The observation findings of students' critical thinking skills, which increased from 57.79% in the first cycle to 75.24% in the second cycle, clarified this. In addition, there was an increase in the average score of the student's critical thinking ability test in the first cycle, which was 298 in the low critical level group to 355 in the high critical level group.

Further research was conducted by (Sumiati, 2018) in his scientific article titled Improving motivation and learning outcomes in chemistry learning through applying of the Problem-Based Learning (PBL) learning model. Research conducted in the classroom Up to 90% expressed interest, happiness, and motivation in learning using PBL methodology. The findings of the study show that using PBL to teach chemical concepts about chemical equilibrium helps improve students' motivation and academic performance.

The latest research is a classroom action research conducted by (Clorawati et al., 2023), with the title Application of Problem-Based Learning Models in Improving Motivation and Learning Outcomes of Chemistry Students. The purpose of this study is to find out how the PBL approach at SMA Negeri 03 Bengkulu City affects student motivation and learning outcomes in chemistry class. All research participants are students in the classroom. Problem-Based Learning (PBL) has several advantages. The approach is that students learn by solving problems and then presenting and analyzing their own work at the end. Students can be encouraged to participate in learning through these exercises. Based on the results of the research, the learning outcomes of pre-cycle students were 58.35%, cycle I was 66.6%, and cycle II was 94.11%. In addition, the percentage of motivated students was set at 58.28%, 62.72%, and 86.22% in the pre-cycle.

In research, similar actions used by teachers to improve chemistry learning outcomes have been reported in a number of related studies. These actions include Classroom Action Research (PTK) using Problem-Based Learning (PBL), one of the learning models. The PBL paradigm is a series of learning activities that start from problems caused by students or teachers and highlight the process of solving difficulties faced scientifically. The use of the PBL learning model in the classroom results in meaningful learning, improvement of critical thinking skills, and development of interpersonal relationships in group projects. Students acquire the ability to solve problems, simultaneously combine knowledge and skills, and apply them in relevant situations. Students become more engaged and motivated in their chemistry classes (Suswati, 2021).

Teachers apply the learning model, PBL because it has several advantages in problem solving, including: (1) challenging students' abilities (2) improving student learning activities, (3) helping students transmit knowledge in order to understand real-life difficulties (4) helping students with their new knowledge (5) developing in the learning they do, and (6) students feeling happy and liking the application of PBL learning. Chemistry learning is systematic, regularly scheduled and connected, while PBL learning is a comprehensive learning strategy that includes problem-solving and problem-finding components. Based on the findings of the study, children who receive learning using PBL have better learning outcomes than those who receive learning using the traditional paradigm. In this way, it can be concluded that the application of the PBL learning paradigm can improve students' learning performance, especially in chemistry courses. This is in based on Ridwan's statement in Suarsani (2019) that PBL can improve students' cognitive, emotional, and psychomotor learning outcomes.

CONCLUSION AND RECOMMENDATION

A. Conclusion

Problem-Based Learning (PBL) is a student-centered teaching approach that emphasizing problem-solving to improve comprehension. Teachers play a crucial role in designing a curriculum that integrates PBL effectively, ensuring that students are actively engaged in learning. This approach has been shown to increase student participation, deepen conceptual understanding, and enhance the overall learning experience.

A review of ten related studies confirmed that PBL has a positive impact on student learning outcomes, particularly in high school chemistry. The lowest score in cycle I was 31.11%, and the best score was 100% in cycle II. From this study, the average increase obtained when applying the PBL model to chemistry learning was 22.83%. By implementing PBL, students not only develop a scientific mindset but also build motivation for group collaboration, strengthen interpersonal skills, and foster an intrinsic desire to learn. Additionally, PBL supports the development of cognitive, emotional, and psychomotor learning, making it a valuable strategy for improving classroom engagement and academic achievement.

B. Recommendation

To optimize the application of Problem-Based Learning (PBL) in high school chemistry, further research should be focused on identifying and addressing potential challenges in its application. Investigating factors such as teacher readiness, student adaptability, and resource availability will help refine strategies for effective implementation. In addition, future research may involve classroom-based trials with students of varying levels of ability to collect more comprehensive empirical data. This will ensure that PBL's recommendations can be adapted to diverse learning environments and effectively improve student learning outcomes.

ACKNOWLEDGMENT

The author would like to express appreciation to all parties who have provided guidance, support, and resources during the research and writing process.

REFERENCES

Addiin, I., & Redjeki, T. (2014). Application of Project Based Learning (PjBL) Learning Model on Acid and Base Solution Subject Matter in Class XI Science 1 SMA Negeri 2 Karanganyar Academic Year 2013/2014. 3(4).

Alamiah, U. S., & Afriansyah, E. A. (2017). Comparison of Students' Mathematical Communication Skills between those who Obtained Problem-Based Learning Models with Realistic Mathematics Education and Open-ended Approaches. Mosharafa, 6(2), 207–216.

Antara, I. P. P. A. (2022). Problem-Based Learning Model to Improve Chemistry Learning Outcomes on the Subject of Thermochemistry. Journal of Education Action Research, 6(1), Art. 1. https://doi.org/10.23887/jear.v6i1.44292

Ariandi, Y. (2017). ANALYSIS OF PROBLEM-SOLVING ABILITY BASED ON LEARNING ACTIVITIES IN THE PBL LEARNING MODEL. PRISMA, Proceedings of the National Seminar on Mathematics, 579–585.

Asriningtyas, A. N., Kristin, F., & Anugraheni, I. (2018). APPLICATION OF PROBLEM-BASED LEARNING MODEL TO IMPROVE CRITICAL THINKING SKILLS AND MATHEMATICS LEARNING OUTCOMES OF GRADE 4 ELEMENTARY STUDENTS. Journal of Mathematics Education Work, 5(1), Art. 1. https://doi.org/10.26714/jkpm.5.1.2018.23-32

Clorawati, A. R., Dewi, K., & Amir, H. (2023). THE APPLICATION OF THE PROBLEM-BASED LEARNING MODEL IN IMPROVING THE MOTIVATION AND LEARNING OUTCOMES OF CHEMISTRY STUDENTS.

Handayani, A., & Koeswanti, H. D. (2021). Meta-analysis of Problem-Based Learning (PBL) learning model to improve creative thinking skills. Journal of Basicedu, 5(3), 1349–1355. https://doi.org/10.31004/basicedu.v5i3.924

Herlina, H. (2020). Application of Problem-Based Learning to Improve Chemistry Learning Outcomes on Hydrocarbon Materials. PENDIPA Journal of Science Education, 4(3), Art. 3. https://doi.org/10.33369/pendipa.4.3.7-13

Hikmi, R., Hasanah, F., & Sutiani, A. (2019). The Effect of Problem-Based Learning Model with Audio Visual Media and Real Laboratory of Acid-Base Materials on Learning Outcomes: Talenta Conference Series: Science and Technology (ST), 2(1), Art. 1. https://doi.org/10.32734/st.v2i1.360

Indrayani, P. (2013). Analysis of Macroscopic, Microscopic, and Symbolic Understanding of Acid-Base Titration of Class XI Science High School Students and Efforts to Improve It with a Microscopic Approach. Journal of Science Education, 1(2), 109–120.

Jayadiningrat, M. G., & Ati, E. K. (2018). IMPROVING PROBLEM-SOLVING SKILLS THROUGH THE PROBLEM-BASED LEARNING (PBL) LEARNING MODEL IN CHEMISTRY SUBJECTS. Indonesian Journal of Chemistry Education, 2(1), Art. 1. https://doi.org/10.23887/jpk.v2i1.14133

Kristiana, T. F., & Radia, E. H. (2021). Meta Analysis of the Application of Problem-Based Learning Model in Improving Science Learning Outcomes of Elementary School Students. Basicedu Journal, 5(2), Art. 2. https://doi.org/10.31004/basicedu.v5i2.828

Latief, H. M. A. (2016). Research on English Learning Classroom Action. Journal of Educational Sciences, 10(2), Art. 2. https://doi.org/10.17977/jip.v10i2.230

Mahmudi, I., Athoillah, M. Z., Wicaksono, E. B., & Kusuma, A. R. (2022). Taxonomy of Learning Outcomes According to Benjamin S. Bloom. Madani Multidisciplinary Journal, 2(9), Art. 9. https://doi.org/10.55927/mudima.v2i9.1132

Meutia, C. (2021). Improvement of Learning Outcomes and Students' Critical Thinking Skills in Chemical Calculation Materials Through the Problem-Based Learning Learning Model. Journal of Educational Performance (JKK): Facilities of Educator Career and Educational Scientific Information, 3(1), Art. 1.

Nurgiansah, T. H., Pratama, F. F., & Iman Nurchotimah, A. S. (2021). RESEARCH ON CLASSROOM ACTION IN CIVIC EDUCATION. Journal of PKN Education (Pancasila and Citizenship), 2(1), 10. https://doi.org/10.26418/jppkn.v2i1.41752

Panggabean, S., Robinson S, P., Hari S. D, K., Bagus P, I. N., Junaidy, & Syaharuddin. (2021). Simulation of Exponential Moving Average and Single Exponential Smoothing: A Comparison of Forecasting Method Accuracy. Journal of Thought and Research in Mathematics Education, Vol. 4 No. 1.

Rahayu, D. S., & Fitriza, Z. (2021). Identification of Students' Misconceptions on Chemical Bond Materials: A Literature Study. EDUCATIVE: JOURNAL OF EDUCATIONAL SCIENCES, 3(3), 1084–1091. https://doi.org/10.31004/edukatif.v3i3.510

Rhem, J. (1998). Problem-Based Learning: An Introduction. The National Teaching & Learing Forum,.

Ristiyani, E., & Bahriah, E. S. (2016). Analysis of Difficulties in Learning Chemistry for Students at SMAN X South Tangerang City. Journal of Science Research and Learning, 2(1), 18. https://doi.org/10.30870/jppi.v2i1.431

Rosyidah, U. (2016). The effect of the jigsaw-type cooperative learning model on the mathematics learning outcomes of grade VIII students of SMP Negeri 6 Metro. SAP (Educational Article Draft), 1(2).

Saputri, F. D., Yamtinah, S., & Susilowati, E. (2020). Application of LKS-Assisted Project Based Learning Learning Model on Acid-Base Materials to Improve Activities and Learning Achievement of Grade XI Students of SMA Batik 2 Surakarta for the 2018/2019 Academic Year. Journal of Chemistry Education, 9(1), Art. 1. https://doi.org/10.20961/jpkim.v9i1.33906

Suarsani, G. A. (2019). Improving Chemistry Learning Outcomes with Elemental Chemistry Subject Matter Through the Application of the Problem-Based Learning Learning Model Improving Chemistry Learning Outcomes with Elemental Chemistry Subject Matter Through the Application of the Problem-Based Learning Learning Model. Journal of Pedagogy and Learning, 2(1), Art. 1. https://doi.org/10.23887/jp2.v2i1.17607

Sumiati. (2018). Improving Motivation and Learning Outcomes in Chemistry Learning Through the Application of the Based Learning (PBL) Learning Model. Ideguru: Journal of Teacher's Scientific Work. https://jurnal-dikpora.jogjaprov.go.id/index.php/jurnalideguru/article/view/46

Suriyanto, D., Taufik, L., & Mubarak, S. (2020). The Effect of the STAD Type Cooperative Learning Model on the Learning Outcomes of Acid-Base Material. SPIN JOURNAL OF CHEMISTRY & CHEMISTRY EDUCATION, 2(2), Art. 2. https://doi.org/10.20414/spin.v2i2.2696

Susanty, H. (2023). The Application of Post-Pandemic Problem-Based Learning (PBL) to Improve Learning Outcomes of Chemistry Learning of Acid-Base Materials in Class XI Science 3 MAN Kapuas Students for the 2022/2023 Academic Year | Hero of the Journal of Education-Social-Cultural Sciences. https://ojs.uvayabjm.ac.id/index.php/pahlawan/article/view/560

Sane. (2008). Project Based Learning: Learning and Learning in the Context of Work. Gantengkali Journal, Volume 3, 11–12.

Widyarsih, E. (2020). Implementation of Problem-Based Learning Model in Improving Student Learning Outcomes of Acid-Base Solution Material. MADRASCIENCE: Journal of Islamic Education, Science, Social, and Culture, 2(2), Art. 2.

Yeni, D. F., Putri, S. L., & Setiawati, M. (2022). The Effect of Student Learning Motivation on the Learning Outcomes of SMP N 1 X Koto Students Above. PROMOTION (Journal of Economic Education), 10(2). https://doi.org/10.24127/pro.v10i2.6591

Yulianti, E., & Gunawan, I. (2019). Problem-Based Learning (PBL) Learning Model: Its Effect on Concept Understanding and Critical Thinking. Indonesian Journal of Science and Mathematics Education, 2(3), Art. 3. https://doi.org/10.24042/ijsme.v2i3.4366

Zakiyah, Z., Ibnu, S., & Subandi, S. (2018). Analysis of the Impact of Student Difficulties on Stoichiometry Materials on Thermochemistry Learning Outcomes and Efforts to Reduce It with Problem Solving Methods. EduChemia (Journal of Chemistry and Education), 3(1), 119–134.

Zulkhairi, Z. (2022). Literature Studies: Analysis of Students' Misconceptions on the Topic of Chemical Bonding. Journal of Science Education Studies, 2(1), 133–140.