



REVIEW OF THE LITERATURE ON THE USE OF PROBLEM-BASED LEARNING MODELS IN CHEMISTRY EDUCATION AND THEIR OUTCOMES

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Abstract

This study reviews the effectiveness of Problem-Based Learning (PBL) in improving student learning outcomes in chemistry education. Traditional teacher-centered approaches often dominate classroom practice, limiting student engagement and resulting in low achievement levels. To address this issue, a literature review was conducted by analyzing twenty peer-reviewed journal articles published between 2020 and 2024 and indexed in Google Scholar and SINTA. The review applied descriptive qualitative analysis, with findings synthesized from tables of selected studies. Results consistently demonstrate that PBL enhances students' academic achievement, critical thinking skills, collaboration, motivation, and ability to connect concepts with real-world contexts. Across different chemistry topics—such as thermochemistry, hydrocarbons, chemical bonding, equilibrium, and redox reactions—PBL was shown to increase student activity levels, improve test scores, and raise completion rates across learning cycles. The review highlights that PBL fosters a student-centered learning environment, enabling learners to actively construct knowledge, solve problems scientifically, and develop essential 21st-century competencies. Therefore, it is recommended that chemistry educators adopt and integrate the PBL model into their teaching practices to improve both cognitive outcomes and student engagement.

Keywords:

Problem-Based Learning, Chemistry Learning Outcomes, Literature Review

INTRODUCTION

One of the natural scientific fields that works in tandem with other fields, including physics, biology, geology, and astronomy, is chemistry (Subagia, 2014). Among the families of natural sciences is chemistry. According to Artini and Wijaya (2020), science studies natural events through accurate observations made on target, using proper techniques and conclusions. Chemistry is viewed as a process and a product since it is one of the scientific families (Hemayanti et al., 2020). Among the numerous intricate subfields of natural science is chemistry, which includes food, medicinal, organic, inorganic, and biochemistry, among other highly complicated subfields (Harwanto, 2019). Beginning with foundational chemistry resources, students receive this lesson in chemistry when they enroll in Senior High School (SHS) grade 10 (Sariwati et al., 2023). Chemistry instruction is intended to help students comprehend the natural world more deeply by broadening their knowledge and developing their analytical skills (Simatupang, 2021). For natural science instruction in schools to be more meaningful, it should prioritize grasping key ideas and their connections to real-world situations (Adnyana & Yudaparmita, 2023).

Because students need help understanding the information supplied, the existing method of instruction, which is still centered on books and resources provided by the teacher, becomes less participatory (Fauzi & Yusuf, 2022). However, the way that chemistry is now taught needs to be revised. The issue frequently arises in the industry is that teachers frequently employ traditional teaching strategies and explain the content with student worksheets or package books (Effendi et al., 2021). Furthermore, according to Wibowo and Pardede (2019), the instructor needed to employ a learning model during the teaching process that would have supported the material's explanation (Wibowo & Pardede, 2019a). The main reason for the teacher's source is low student learning outcomes. Where educators continue to have a great deal of control over the learning process and do not apply cutting-edge teaching techniques (Wardana & Warsi, 2024). The teacher aspect is one of the many variables affecting the learning process's effectiveness. Teachers are a vital part of the education staff, responsible for executing the learning process. A teacher is expected to be familiar with the learning model.

According to Ariyani's (2006) study at SMA 12 Semarang, students in class XI IPA1 at SMA 12 Semarang continue to have low chemistry learning outcomes; on average, they score 56.74 for acid and base solution material and 61.16 for stoichiometry material, with a classical completeness of 37.21% and 25.58%, respectively (Muderawan et al., 2019). 53% of students in class XI MIPA had yet to finish the buffer solution material, according to a study done by Kadek in 2020. The research involved data on the outcomes of daily tests of buffer solutions given by chemistry professors at SMA Negeri 2 Kuta. These poor chemistry learning outcomes show pupils still need help understanding the subject (Kadek & Nyoman, n.d.). The learning outcomes of elemental chemistry materials are meager (average 60.05), according to early observations made by researchers through teaching and learning activities at SMA Negeri 1 Praya Tengah. Despite several initiatives by teachers to improve student learning outcomes, the results of the first-semester test of the 2017-2018 academic year are the same, at 60.55, and are still considerably below expectations (Rostika, 2020)

Learning models that engage students throughout the learning process must be innovated to solve these issues. To overcome difficulties, consider using the Problem-Based Learning (PBL) learning model. In PBL, students are divided into small groups and collaborate to solve a problem that teachers and students decide on regarding the subject matter. The Problem-Based Learning (PBL) approach requires students to participate in active group discussions to solve problems and generate new ideas. Students frequently employ various problem-solving techniques when the teacher uses the learning model. Students must, therefore, unavoidably read aloud and explain the teacher's material explanations. Additionally, to address issues raised by discussion questions, they must proactively look for more information from various sources (Aristawati & Sadia, 2018). According to Langitasari et al. (2021), PBL is a type of student-centered learning that enables learners to carry out research, integrate theory and practice, and apply their skills and knowledge to create practical answers to issues that are put before them (Langitasari et al., 2021). Yola Adhysta (2014) conducted research and discovered that using the Problem-Based Learning (PBL) Compared to the usual learning model on compound name material, the model with paired card media improves student chemistry learning results by 69.31% (Silaban et al., 2020). Students are initially assigned a problem at the start of the learning process, which they examine, analyze, and solve. To facilitate students' inquiries, teachers should pose various challenges and questions (Rerung et al., 2017).

The problem-based learning model is one of the instructional strategies that can help students understand lessons by linking the subject to real-world situations. To acquire information and problem-solving skills, students who use the problem-based learning approach tackle a problem using the scientific method (Isma et al., 2022). Students who use the Problem-Based Learning approach can recognize problems, determine causal linkages, and apply relevant concepts to the given situation (Rais & Suswanto, n.d.). Numerous parties are expected to find value in the study's findings. First, it is expected that this research would boost students' enthusiasm to continue actively participating in classroom learning activities, resulting in greater learning results. Second, schools should use teacher input and performance as feedback to improve student learning outcomes and overall school quality. Third, problem-based learning can benefit in enhancing learning outcomes by giving teachers input on how effective it is in raising student learning outcomes. Fourth, researchers can consult and consider the study's findings when they undertake more research on related subjects (Alifah et al., 2019).

The teacher's assessment allows for determining the pupils' comprehension or absorption rate of the taught subject. The student's learning outcomes are one source of information used to

quantify student learning outcomes—proof of the effort put into learning, as determined by exams. According to Jamil (2019), "learning outcomes are the results achieved in an effort, in this case, learning efforts in the realization of student learning achievements seen in every test given" (Pradana, 2017); this is in line with what was said.

METHOD

This study applied a literature review approach with a descriptive qualitative design. The purpose of this method was to synthesize and analyze existing research findings on the implementation of Problem-Based Learning (PBL) in chemistry education and its impact on student learning outcomes. The data sources consisted of twenty peer-reviewed journal articles published between 2020 and 2024, which were accessed primarily through the Google Scholar and SINTA databases.

The process began with identifying and selecting relevant articles by using specific keywords such as Problem-Based Learning, chemistry education, and learning outcomes. Only articles that met predetermined inclusion criteria were considered, namely those published within the designated timeframe, focused on the use of PBL in chemistry subjects, and presenting empirical findings regarding student achievement, motivation, or skills. Articles outside the timeframe, not related to chemistry education, or lacking empirical data were excluded.

After the selection stage, all relevant articles were organized into a data extraction table to facilitate analysis. The table summarized essential information including the research title, author(s), research design, sample or subject, chemistry topic studied, and main results. This systematic documentation allowed for a clear comparison across studies.

The collected data were then analyzed using a descriptive qualitative technique. This involved examining patterns, similarities, and differences in how PBL was applied and its effectiveness in improving various aspects of chemistry learning outcomes. The analysis focused on indicators such as student test scores, completion rates, classroom participation, motivation, and critical thinking development. By synthesizing findings from multiple sources, this method provided a comprehensive understanding of the benefits and challenges of implementing PBL in chemistry classrooms.

FINDINGS AND DISCUSSION

Findings

A Classroom Action study journal was obtained after analyzing the literature on numerous relevant study findings about the use of the Problem-Based Learning (PBL) learning paradigm and student learning outcomes in Chemistry themes. The table below analyzes how PBL is used to enhance the learning outcomes for students in Chemistry courses:

Table 1. Analysis of the Use of Problem-Based Learning (PBL) Model to Enhance Chemistry Learning Outcomes

No	Research Title	Researcher	Research Methods	Results
1	Applying a Problem-Based Learning Model to Enhance Chemistry Subject Learning Results	(Despita & Makmur, 2022)	This research uses the Scientific-TPACK approach with the type of class action research,	The study's findings demonstrated that: (1) the average value was 60 in cycle I with 40% completeness; (2) the average value grew to 79 in cycle II with 80% completeness; and (3) the

			with observation and test techniques.	average value reached 86 in cycle III with 90% completeness. As a result, using the Problem-Based Learning Model enhances students' comprehension of chemical topics.
2	Implementing a Problem-Based Learning Approach to Enhance Chemistry Learning Results in the Thermochemistry Subject	(Antara, 2022)	A classroom action research design was employed in this study. In this study, PBL learning is implemented in the thermochemistry subject through student worksheets (LKS) that the study's subject matter experts prepare.	The pre-cycle average value of 76.54 with 71.43% learning completeness, the cycle I average of 80.77 with 88.57% learning completeness, and the cycle II average of 84.49 with 100% learning completeness all show this direction. Thus, the Problem-Based Learning technique has the potential to improve learning outcomes in thermochemistry.
3	Using Problem-Based Learning to Improve Chemical Education for Hydrocarbon Substances	(Herlina, 2020)	The Classroom Action Research approach and test and observation methodologies were applied in this study.	Cycle II research results indicated a 60% increase in student activity and learning outcomes compared to cycle I, specifically 69.47. In cycle II, students achieved an average post-test score of 78.53 and a 92% completion rate for learning outcomes with a score of ≥ 70 . The outcomes of observations of learning by applying problem-based learning strategies get favorable reactions from students. This demonstrates how problem-based learning benefits students throughout the teaching and learning process.
4	Improving Chemical Equilibrium Concept Learning Outcomes Through a Problem-Based Learning Model	(Astuti, 2019)	This study used classroom action research to monitor test-taking, teacher, and student behavior.	When the PBL (Problem-Based Learning) learning paradigm was applied to chemical equilibrium, learning outcomes improved significantly during Cycle II. In cycle I, the average post-test result was 67.33; student learning completeness only reached 63.89%. In cycle II, students' learning

				completeness reached 86.11%, and the average post-test performance increased to 77.56. It is acceptable to conclude that using the PBL (Problem-Based Learning) teaching method increases students' understanding of chemical equilibrium.
5	Using the Problem-Based Learning (PBL) Model to Improve Chemical Bonding Material Learning Outcomes for Class X Mipa 6 SMA Negeri 1 Matauli Pandan Students	(Siregar, 2022)	This study is part of the class action research project, including test procedures, an observation sheet, and a questionnaire.	According to data analysis, the proportion of instructor activity in cycle I was 93%, and in cycle II it was 98.5%. Furthermore, during cycles I and II, student participation grew by 86.67% and 95.83%, respectively. In their remarks, 91.43% of students said they enjoyed learning about chemical bonding using the PBL paradigm. In cycle I, the degree of classical completeness of student learning outcomes grew by 57.14%, whereas cycle II increased by 88.57%. This implies that using a Problem-Based Learning (PBL) technique can improve students' understanding of chemical bonding materials.
6	Improving Chemistry Student Learning Outcomes with the Problem-Based Learning Model for Class X Students at SMAN 6 Mataram.	(Lembayung et al., 2023)	Collaborative Classroom Action Research (PTK), involving peers, student teachers, and supervisors, was the type of research that was done.	In cycle one, students scored an average of 48.84, indicating a 20.50% completion rate for classical study. In cycle two, students scored an average of 78.78, indicating an 88.2% completion rate for classical study. In cycle three, students achieved an average of 87.66, indicating that 97% of classical learning was completed. Thus, employing the PBL paradigm to teach class X chemistry can considerably improve student learning outcomes.
7	Improving Students' Learning Outcomes and Critical Thinking Capabilities with Problem-Based Learning	(Cut Meutia, 2021)	The research type is class action research, the data source is all students in Class X MIPA 5, and the collection	The observation of students' critical thinking abilities, which increased from 57.79% in cycle I to 75.24% in cycle II, confirms this. Furthermore, data from the students' critical thinking exam results indicated a rise, with the cycle I average score

	Materials in Chemical Calculation		techniques are tests and observations.	falling into the low criticality group at 298 and rising to 355 in cycle II, which falls into the high criticality category. According to cycle I and cycle II research findings, including the PBL learning paradigm into chemistry learning materials on chemical names in class X MIPA 5 SMA Negeri 1 Banda Aceh can increase students' critical thinking skills.
8	Implementing a Problem-Based Learning Model and a Culturally Responsive Teaching Approach to Optimize Chemistry Learning Outcomes	(Wahyuningsih et al., 2023)	This study uses an action research approach in the classroom and a lesson study model.	According to the findings of this class action research (PTK), using problem-based learning in cycle I in combination with a culturally relevant teaching technique did not affect student learning results, with 77.78% of students receiving a score of 78 or above. Cycle II showed improved learning outcomes compared to cycle I, with 55.55% of students receiving a score of ≤ 78 . Furthermore, 86.11% of students in the third cycle got a score of ≥ 78 , suggesting that the level of classical completeness (85%) was met. According to this class action study (PTK), Combining the Problem-Based Learning (PBL) learning model with a Culturally Responsive Teaching method can increase student learning outcomes, as evidenced by improvements observed across cycles I, II, and III.
9	Using a Problem-Based Learning Model with Multimedia Support to Enhance Students' Chemistry Learning Activities and Assessment Results.	(Santi et al., 2021)	Classroom Action Research (CAR) is the type of research carried out.	Teacher activity averaged 23 in the first cycle but increased to 25.5 in the second cycle. In the first cycle, students' average activity acquisition score was 20, while in the second cycle, this rose to 25. Children's cognitive learning scores also improved from 41.67 in the first cycle to 80.3 in the second cycle. Therefore, using a problem-based learning approach coupled with

				Faraday's Principle material can improve student learning activities and outcomes. Therefore, educators can choose to use PBL models and multimedia support for learning through face-to-face teaching.
10	Implementation of Problem-Based Learning Model through Culturally Responsive Teaching (CRT) to Improve Learning Outcomes and Motivation of Students in Chemistry Subject of Class X IPA 2 SMA Negeri 7 Mataram in the Academic Year 2022-2023	(Sari et al., 2023)	This study is an example of classroom action research or CAR, and it collects data through observation, questionnaires, learning outcomes, and daily journals.	Findings indicate that combining problem-based learning techniques with culturally responsive teaching can increase student motivation (89% agreement rate). As a result of the problem-based learning approach combined with culturally responsive teaching, students were highly motivated, with an 89% agreement rate. Additionally, the data showed an increase in student engagement, with an average percentage of 60.96% in cycle one and 87% in cycle two. In addition, student learning outcomes are improving, with learning completion increasing by 77% and 86% respectively from Cycle 1 to Cycle II.
11	To enhance student engagement and academic performance, the Problem-Based Learning (PBL) Model was implemented for the Chemical Equilibrium curriculum at SMAN 3 Bengkulu City.	(Maulana et al., 2021)	This study is a three-cycle classroom action research project (CAR).	Upon analyzing cycles I, II, and III, it was evident that there was a notable rise in both student engagement and completion rates. The equivalent percentages of learner activity are 32.37%, 55.25%, and 84.76%. However, the comparable percentages of students' learning completion are 17%, 31.4%, and 82.8%. The findings showed that employing the problem-based learning paradigm successfully increased students' activity levels and learning objectives by more than 75%.
12	Implementing Problem-Based Learning (PBL) in the Post-Pandemic Era to	(Susanty, 2023)	In addition to descriptive research, this study is an action study. Ways for	Learning completeness with the PBL learning method, traditionally 92% with an average score 82.5, has worked well. The results of learning

	Enhance Chemical Learning Outcomes for Students in Class XI IPA 3 MAN Kapuas Academic Year 2022–2023 by Using Acid-Base Material		gathering data include formative assessments, student and teacher activities, and observing how PBL learning delivery systems are processed.	activities carried out for two cycles, both from observations and evaluating learning activities with the PBL method, increased learning completeness from 69% to 92%. Additionally, the average score for learning outcomes increased from 70.8 to 82.5.
13	Incorporating a Problem-Based Learning Model for the 2020-2021 academic year at SMK N 1 Danau Sembuluh Seruyan, in Central Kalimantan, was aimed at enhancing the cognitive learning outcomes of Class X students in Chemistry, specifically focusing on the Basic Law of Chemistry and Molecular Concepts.	(Maulana et al., 2021)	As part of the Classroom Action Research (CAR) approach, this study incorporates direct observation data to examine the classroom learning process. The collection of data was conducted through written tests and various observational methods.	The study's findings demonstrated that using the problem-based learning paradigm helped students achieve better learning results in the cognitive domain, with cycle I average student learning outcomes rising to 57.89, cycle II to 69.47, and cycle III to 81.05. In cycles I, II, and III, the proportion of classical completeness likewise rose to 52.63%, 73.68%, and 89.47%.
14	Enhancing Students' Chemistry Learning Outcomes with Reaction Rate Material by Using the Problem-Based Learning (PBL) Model in Differentiated Instruction	(Ashilah et al., 2023)	This study was carried out in two cycles as a Classroom Action Research (CAR). Multiple-choice evaluation tests were administered after each cycle to gather data on learning results.	Following descriptive statistical analysis, it was discovered that student learning results had increased by 14.34% from cycle I, which is 75.76%, to cycle II, which is 90.10% in terms of classical completeness. Students' learning results with regard to reaction rate material can be improved by combining tailored instruction with a problem-based learning paradigm.
15	Enhancing the Activity and Learning Outcomes of Redox and	(Mulyati, 2021)	This study employs a qualitative methodology and a two-cycle	Regarding the learning objectives and student activities in cycle I, just eighteen individuals met the minimum requirements or had a 50%

	Electrochemistry Materials through Problem-Based Learning Model		classroom action research paradigm. Pre-cycle motivation surveys, learning evaluations after cycles I and II, and end-of-cycle questionnaires were used to gather data.	completeness rate with an average score of 68. The students' participation during the cycle was only 48%, but the questionnaire indicated a 59% response rate. 60% of people are active on average. Students who meet the completeness of 31 people, or 86%, with an average score of 84, demonstrate improved learning outcomes in cycle II. Based on observations from cycle II, student involvement in discussions increased to 78%; based on questionnaires, student activity in discussions was 72%; average activeness improved by 14% to 74%.
16	By implementing the Problem-based Learning (PBL) learning model, SMA Negeri 4 Mataram has successfully improved student learning outcomes in Chemistry Class X-6, thus enhancing their educational experience.	(Baqiyatusshalihah et al., 2023)	The Kemmis and Taggart methodology, carried out in two cycles, provides the basis for this study's collaborative classroom action research (CAR) model.	Pre-class action research at SMA Negeri 4 Mataram reveals that the percentage of learning outcomes for class X-6 students is 2.86% with a category of less, 68.75% with a sufficient category in cycle I, and 74.26% with a suitable category in cycle II. Based on the research results, it can be concluded that students enrolled in the X-6 class at SMA Negeri 4 Mataram have successfully implemented the problem-based learning approach in their chemistry courses, resulting in improved academic achievements.
17	Using Problem-Based Learning (PBL) Learning Model to Improve Learning Outcomes of Chemistry Students in Classes X-6 at SMA Negeri 4 Mataram	(Maimunah, 2022)	Class action research (CAR) is the term for this kind of study, a method for gathering data that combines tests and non-tests.	With no students passing (0% in the pre-cycle), 12 passing (50%) in cycle I, and 20 passing (83%) in cycle II, the findings showed that student learning outcomes had improved.
18	Using a Problem-Based Learning Approach to Improve Electron	(Mustatiroh et al., 2023)	The researchers used a three-cycle class action research design for their study.	The results show that introducing a problem-based learning model can improve student learning outcomes. The average number in the first

	Configuration Chemistry Learning Outcomes		Using observation and assessment methods, data was gathered after each learning cycle. Discussions and the Scientific-TPACK methodology were the methods employed.	cycle was 65, with a completion rate of 40%; in the second cycle, it increased to 76, with a completion rate of 73%; in the second cycle, it reached 84, with a completion rate of 100%.
19	Implementation of an Online-Based Problem-Based Learning Approach to Enhance Basic Chemistry Analysis Learning Outcomes on Solution Concentration for SMKN 1 Duduksampeyan Gresik Class X TMI-2 Students	(Khabibah, 2021)	This study is being conducted as a class project.	The average post-test score for cycle I was 71.7. Twenty-eight pupils, or 77.8%, have attained learning completion. Eight pupils, or 22.3%, still need to attain learning completeness. Cycle II saw an average post-test result score of 79.3 and an 88.9% level of completeness in classical learning. This indicates that 32 of the 36 pupils have finished their education.
20	Improving learning outcomes and self-efficacy in electrolyte and non-electrolyte solution materials using a problem-based learning model	(Halnas et al., 2022)	This study used two learning cycles of classroom action research (CAR).	The results of the study showed that from the first cycle to the second cycle, students' self-efficacy increased from the "pretty good" category to 58.58, with a value of 49.69, which was classified as "good". ; Students' learning outcomes in terms of knowledge completion increased from 51.43% to 88.57%; students' evaluation of their attitudes increased from "not bad" (6.325) to "suitable" (10.04); students' skills increased from Progressed from "fairly competent" with a score of 51.04% to "competent" with a score of 71.04%. In addition, students responded well to the enthusiasm for the application

				of the problem-based learning model, with a score of 38.74.
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Discussion

By examining 20 research articles from Indonesian journals, this literature review-based study sought to determine the impact of applying problem-based learning (PBL) learning paradigm on students' learning chemical reasoning abilities. The outcomes demonstrate that using the PBL framework can assist students in improving their arguing when studying chemistry. The use of PBL models can substantially impact students' critical thinking abilities, teamwork abilities, academic accomplishment, and learning outcomes in addition to their ability to argue.

The examined research indicates that PBL improves students' ability to argue effectively. This is in line with studies conducted by Despita & Makmur et al. (2022), which show that learners are encouraged to provide solutions to problems when they are given. Because of this, to argue for the problem's applicability to real-world situations, these students must converse and collaborate with other group members throughout the problem-solving process. Therefore, PBL learning will enhance student learning outcomes through problem-solving.

The most effective teaching strategies support students in gaining and improving the 21st-century abilities they'll require, particularly in problem-solving and critical thinking, teamwork, and communication. These abilities can be put into practice through efficient classroom teaching. The learning process includes several crucial elements, such as developing critical thinking abilities, outlining processes, and creating questions. In chemistry classes, the PBL paradigm can raise the significance of the learning results for students.

A problem-based learning approach motivates students and consolidates their knowledge. Other researchers have corroborated the findings of this study, showing that using problem-based learning models can improve student learning outcomes (Lumban Gaol, 2020). According to some researchers (Intan et al., 2023), problem-based learning approaches can improve student learning outcomes, teacher-led instruction, and student-led activities. According to related studies, the problem-based learning approach impacts students' capacity to solve chemical puzzles (Woa et al., n.d.).

The results of the review indicate that using a problem-based learning approach can improve student learning objectives (the content of chemistry courses). Research has successfully demonstrated that students can think critically and actively develop their knowledge by interacting with learning environments created by learning facilitators (teachers). Student-centered, problem-based learning strategies are designed to enhance intellectual, problem-solving, and cognitive abilities. Using a problem-based learning paradigm has many benefits for students, including increased focus during study, connecting problems to real-world situations, improved collaboration among students, and more meaningful learning.

CONCLUSION

The findings and literature review of nine relevant studies show similarities, suggesting that the use of problem-based learning (PBL) models can improve student learning outcomes, particularly in chemistry courses. The PBL paradigm allows students to cultivate a scientific mindset, become actively involved in their education, build motivation for group projects and interpersonal relationships, create internal motivation for learning, and increase the participation of educators and learners in the educational process. Based on the study's findings, the author recommends that educators, particularly those who teach chemistry, employ the PBL learning paradigm when teaching students about chemical issues because it can help them achieve their learning objectives. As long as the students can complete the learning phases, the use of this PBL model needs to be prepared as much as possible.

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