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# LITERATURE REVIEW: APPLICATION OF PROBLEM BASED LEARNING MODEL TO CHEMISTRY LEARNING OUTCOMES

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***Abstract***
*Inappropriate learning methods can affect student learning outcomes. Students who are inactive and only rely on teachers tend to have poor learning outcomes, so the learning process becomes teacher-centered. Given the importance of learning outcomes in chemistry education, this study explores the effectiveness of problem-based learning (PBL) strategies. This analysis is based on twenty publications of national journal articles obtained through Google Scholar with SINTA and Garuda accreditation in the period 2019 to 2023. The data were analyzed using the content analysis method by compiling a table of articles that have been published in scientific journals. This literature study found that the application of a problem-based learning approach can significantly improve student performance in class, especially in understanding concepts and achieving learning outcomes.*

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

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## INTRODUCTION

Chemistry is a branch of natural science that studies natural phenomena through observation and appropriate scientific methods (Subagia, 2014). Chemistry is a branch of natural science. As stated by Artini and Wijaya (2020), science studies natural phenomena through careful observation in a specific location, using appropriate methods, and drawing acceptable conclusions. Because it belongs to the family of scientific processes, chemistry is often considered as such (Hemayanti et al., 2020). Chemistry is one of the many complex branches of natural science; chemistry includes several subfields, such as biochemistry, organic, inorganic, food, and medicine (Harwanto, 2019). Students in the 10th grade of Senior High School (SMA) start this chemistry course using basic chemical materials (Sariwati et al., 2023). In chemistry learning at the senior high school (SMA) level, a deep understanding is needed so that students are able to develop analytical and critical thinking skills (Simatupang, 2021). Adnyana and Yudaparmita (2023) argue that for science education to be relevant to the real world, students must focus on conceptualizing important concepts and how they relate to real-world phenomena (Adnyana & Yudaparmita, 2023). Current learning techniques still rely on textbooks, which makes the resources provided by instructors less interesting, even if students need the knowledge to understand the lesson (Fauzi & Yusuf, 2022). However, chemistry learning in schools is still dominated by conventional methods such as the use of textbooks and worksheets, which can hinder students' understanding of the concepts taught (Effendi et al., 2021; Wibowo and Pardede, 2019).

One of the main challenges in chemistry learning is the low learning outcomes of students. Studies show that many students have difficulty in achieving the Minimum Completion Criteria (KKM) in various chemistry materials, such as acid-base solutions, stoichiometry, and buffer solutions (Wardana & Warsi, 2024). The main factors contributing to this problem are the low level of student involvement in the learning process and the lack of use of innovative learning methods that can improve the understanding of chemical concepts in depth. Teaching staff, one of the vital components of which is the teacher, are responsible for implementing the learning process. Educators need to master various learning approaches that encourage student engagement. According to Ariyani's (2006) research, the chemistry learning outcomes of class XI IPA 1 students of SMA Negeri 12 Semarang are still not satisfactory and have not reached the KKM. The average for these students was 56.74 for acid-base solutions, 61.16 for stoichiometry material, and 37.21% and 25.58% for classical integrity, respectively (Muderawan et al., 2019). Buffer solution material was not completed by 53% of grade XI MIPA students, according to Kadek's 2020 research. Data from daily tests on buffer solutions given by the chemistry professor of SMA Negeri 2 Kuta were used in this study. According to Kadek and Nyoman, students still need help in understanding chemistry, as indicated by their learning outcomes, which have not yet reached the minimum completion criteria (KKM) (Kadek & Nyoman, 2020). According to preliminary findings from a study conducted at SMA Negeri 1 Praya Tengah, students showed high success in learning the chemical

elements content, with an average score of 60.05. The first-semester test results in the 2017–2018 academic year remained the same, at 60.55, much lower than anticipated, despite several attempts by instructors to improve students' academic success (Rostika, 2020).

Teaching methods that actively involve students in every stage of the process are needed to overcome learning challenges. The PBL paradigm, where students work in small groups to find solutions to real-world problems, can help. Through the PBL strategy, students not only actively participate in class discussions but also collaborate to find solutions and develop their critical thinking skills. By implementing this paradigm, educators encourage students to use various problem-solving strategies and proactively seek information from various sources to overcome obstacles in the learning process (Aristawati & Sadia, 2018).

In problem-based learning (PBL), students are encouraged to investigate a topic independently, draw connections between theory and practice, and develop practical solutions using their knowledge and skills (Langitasari et al., 2021). When compared to more conventional learning methods that focus on chemical name material, research by Yola Adhysta (2014) showed that there was a 69.31% increase in students' chemistry learning outcomes when problem-based learning (PBL) and paired cards were used (Silaban et al., 2020). To learn, students must first face a problem, which they must investigate, evaluate, and solve.

According to Rerung et al. (2017), instructors can inspire student inquiry by providing various challenges and questions (Rerung et al., 2017). The problem-based learning paradigm is an efficient teaching tool that fosters student understanding by connecting classroom material to relevant real-world situations. Isma et al. (2022) found that students who applied a scientific approach to problem-solving learned problem-solving knowledge and skills (Isma et al., 2022). Students who participated in the Problem-Based Learning program demonstrated problem recognition, understanding of cause-and-effect relationships, and applying concepts (Rais & Suswanto, 2017). Many parties will find value in the conclusions of this study. In the long run, better educational outcomes will result from increased student incentives to participate actively in classroom learning activities. Furthermore, it is important to use teacher engagement and effectiveness as feedback mechanisms to improve school quality and student learning outcomes.

This study aims to explore more effective learning strategies in improving students' understanding and learning outcomes in chemistry. The problem-based learning model or Problem-Based Learning (PBL) is one alternative that can be applied to increase students' active participation in solving real problems related to chemical concepts. The application of this model is expected to improve students' critical thinking skills and better learning outcomes. The contribution of this study is to provide insight into the effectiveness of the PBL model in chemistry learning, especially in improving students' understanding of materials that are considered difficult. The findings of this study can be a reference for educators in developing more innovative and interactive learning strategies, so that they can optimize student learning outcomes at the high school level. According to Alifah et al. (2019), problem-based learning also helps instructors see how well they improve student achievement levels, leading to improved learning outcomes (Alifah et al., 2019). Students' understanding and interest in the subject matter can be measured through teacher-led assessments. Student learning outcomes are one way to measure the effectiveness of a program's educational initiatives. In line with the opinion above, Jamil (2019) stated that "learning outcomes are the results achieved in an effort; in this case, learning efforts in realizing student learning achievements are seen in every test given" (Pradana, 2017).

## METHOD

The purpose of this study was to review 20 research papers published in Indonesian language journals to conclude how the use of the PBL (Problem-Based Learning) learning paradigm affects students' ability to argue when learning chemistry. Selecting accredited national journals, such as those indexed in SINTA 3, SINTA 4, SINTA 5, and Garuda, is based on several academic and methodological considerations. First, these journals have gone through a strict assessment process by the Ministry of Education, Culture, Research, and Technology, so that the quality and validity of the published research can be accounted for. Second, by relying on national journals, this research can be more relevant to the educational context in Indonesia, especially in the application of problem-based learning models in chemistry learning. In addition, journals in this category generally use good scientific standards, clear methodologies, and valid and reliable data. Using sources from SINTA 3, SINTA 4, SINTA 5, and Garuda also ensures that the compiled information has been peer-reviewed, increasing the credibility of the analysis conducted in this study. This study aims to test how classroom action research (CAR) through a literature review on problem-based learning (PBL) models can improve chemistry learning outcomes with emphasis on students' active involvement in solving contextual problems. Through the analysis of 20 articles from accredited journals, this study found the effectiveness of PBL in improving students' conceptual understanding, critical thinking skills, and learning motivation, and presented a comprehensive conclusion regarding the effect of PBL on chemistry learning outcomes.

To collect data, we looked at the efficacy of various learning models and analyzed student learning outcomes from various scientific publications. To evaluate the feasibility of this learning model in chemistry classes, we first collected relevant data, then compared it with study articles that used classroom action research methods. This process was carried out by applying content analysis methods to obtain findings that could be analyzed and evaluated based on the research context. Researchers selected articles that used classroom action research methods with chemistry material, then focused the analysis on the Problem-Based Learning (PBL) learning model to assess its effectiveness in improving student learning outcomes. We used Google Scholar using the Publish or Perish program to search for journals related to "problem-based learning models" and "chemical materials" from 2019 to 2023. Our search yielded 20 results. You can get this publication in PDF format; this publication is taken from a prestigious national periodical.

This Study Examines 20 Scientific Papers from Accredited Indonesian Language Journals (Sinta 3, Sinta 4, Sinta 5, And Garuda) To Conclude the Effect of Problem-Based Learning (Pbl) Models On Students' Argumentative Abilities In Chemistry Learning. The Selection of Journals Is Based On Academic Quality, Relevance to Education In Indonesia, And the Validity of The Methodology Used. Using The Content Analysis Method, This Study Evaluates the Effectiveness of PBL In Improving Students' Conceptual Understanding, Critical Thinking Skills, And Learning Motivation. The Articles Analyzed Focus On Classroom Action Research (CAR) with Chemistry Material, Obtained Through A Search On Google Scholar Using The Publish Or Perish Program For The Period 2019–2023.

Metode memuat rancangan penelitian atau desain penelitian, sasaran dan target penelitian (populasi dan sampel), teknik pengumpulan data, model penelitian, dan teknik analisis serta hipotesis (jika ada). Metode ditulis dalam bahasa Indonesia dengan huruf *Times New Roman* ukuran 11 dan spasi 1. Setiap paragraf diberikan baris baru sebanyak satu inci dengan format teks rata kiri kanan.

## RESULT AND DISCUSSION

In this Class Action journal, we will review research on the effectiveness of the Problem-Based Learning (PBL) approach in chemistry teaching and its effects on student achievement. Investigations on the effectiveness of project-based learning (PBL) in improving chemistry students' learning outcomes are shown in the Table 1.

**Table 1.** Results of Problem-Based Learning (PBL) Literature on Chemistry Learning Outcomes

| No | Article Title | Author | Research Methods | Research Result |
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| 1 | "Application of Problem-Based Learning Model to Improve Learning Outcomes in Chemistry" | (Despita & Makmur, 2022) | To test the data collected from observations and classroom assessments, this study used the Scientific-TPACK approach. | The completion of the Problem Based Learning model is a teacher's effort to improve the learning outcomes of students in Chemistry. This study uses a Scientific-TPACK approach with the type of classroom action research. The research was carried out collaboratively, where the researcher was the executor of the action and researcher's colleague was the observer. The subjects of this research were 10 students of class X Engineering SMK Aviation SPAN Pekanbaru. The research was carried out in 3 (three) cycles. The criteria for the success of the action are considered successful if the mastery of learning outcomes increases from cycle 1 to cycle 3. Data collection is carried out using observation and evaluation techniques at the end of learning |

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| | | | | in each cycle. The results of this study indicate that: (1) In the first cycle the average value is 60 with 40% completeness, (2) the average value in the second cycle increases to 79 with 80% completeness, and (3) in the third cycle the average value the average reaches 86 and completeness reaches 90%. Thus, the application of the Problem Based Learning Model can improve students' learning outcomes in chemistry subjects. |
| 2 | "Application of Problem-Based Learning Approach to Improve Chemistry Learning Outcomes in Thermochemistry Subject" | (Antara, 2022) | The investigation used a classroom action research paradigm. This research applied problem-based learning (PBL) to study thermochemistry using Learning Worksheets (LKS) developed by specialists in educational materials. | The way teachers teach often uses conventional methods which causes low student learning outcomes. The purpose of this study is to improve chemistry learning outcomes on the topic of thermochemistry by applying the Problem-Based Learning model. This study is a classroom action research. The subjects in this study were 35 students in grade XI, consisting of 16 male students and 19 female students. The data collection method used a learning outcome test. Data were analyzed using descriptive methods, both qualitative and quantitative data. The results obtained from this study show that Problem-Based Learning can improve students' chemistry learning outcomes. This is indicated by the results obtained in the pre-cycle, an average value of 76.54 with a learning completion of 71.43%, in cycle I reaching an average value of 80.77 with a learning completion of 88.57%, and in cycle II reaching an average value of 84.49 with a learning completion of 100%. Thus, the Problem-Based Learning learning model can improve chemistry learning outcomes on the topic of Thermochemistry. In addition, the Problem-Based Learning model can improve students' critical thinking skills, activeness, creativity, and problem-solving skills. |

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| 3 | "Application of Problem-Based Learning to Improve Chemistry Education of Hydrocarbon Substances" | (Herlina, 2020) | This study used a Classroom Action Research strategy and test and observation methodology. | The aim of this study was to improve student learning outcomes on hydrocarbon material by applying the problem-based learning (PBL) method. The research method used was Classroom Action Research (CAR) which generally consists of 2 (two) cycles. This research was conducted in Class XI IPA 2 at public high school 7 Rejang Lebong with a sample of 25 students. Data collection techniques used were tests and observation sheets. From the results of research in the second cycle, an increase in activity and student learning outcomes from the first cycle was 69.47 with a percentage of 60%. In the second cycle, the average value of 78.53 students' posttest was achieved, and the percentage of completeness of student learning outcomes reached 92%, with score of students ?70. The results of student observations using the problem-based learning method have good responses from students. This proves that learning by using problem-based learning has a positive impact on students in teaching and learning. |
| 4 | "Improving Learning Outcomes of Chemical Equilibrium Concepts with Problem-Based Learning Model" | (Astuti, 2019) | This study used classroom action research. | This research is a classroom action research conducted in two cycles. Each cycle consists of planning, implementation, observation, and reflection. The subjects of the study were students of class XI IPA-1 SMA Muhamadiyah 02 with a total of 36 students consisting of 10 male students and 26 female students. This study aims to improve student learning outcomes in the concept of chemical equilibrium. To achieve this goal, the researcher applied an action design based on the principles of learning design of the PBL (Problem-Based Learning) learning model, including students' critical thinking attitudes and student independence in forming chemical concepts. The principle |

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| | | | | of critical thinking of students with experimental activities and group discussions. Meanwhile, the principle of student independence is carried out with individual problem-solving activities. The results of the study indicate that the increase in learning outcomes of the concept of chemical equilibrium through the PBL (Problem-Based Learning) learning model is the average achievement of student learning outcomes in each cycle, namely 67.33 in cycle I, and 77.56 in cycle II. |
| 5 | "Application of Problem-Based Learning (PBL) Model to Improve Learning Outcomes of Chemical Bonding Materials of Class X Mipa 6 SMA Negeri 1 Matauli Pandan Students" | (Siregar, 2022) | Together with assessments, observations, and questionnaires, this research is a component of a classroom action project. | Chemical bonding material is a material that is considered difficult by students because to understand the material they must know the Lewis structure and various types of chemical bonds. Therefore, the author uses the Problem-Based Learning (PBL) learning model to improve the learning outcomes of students at SMA Negeri 1 Matauli Pandan. This research is a Classroom Action Research (CAR) which is carried out in 2 cycles. The analysis data shows that the percentage of teacher activity results in cycle I is 93% and in cycle II is 98.5%. The results of student activity also increased in cycle I by 86.67% and in cycle II by 95.83%. The percentage of student responses who like learning using the PBL model on chemical bonding material is 91.43%. The classical completeness level of student learning outcomes increased significantly in cycle I by 57.14% and in cycle II by 88.57%. This shows that the application of the Problem-Based Learning (PBL) learning model can improve student learning outcomes on chemical bonding material. |
| 6 | "Improving Students' Chemistry Learning Outcomes through the Use of | (Lembayung et al., 2023) | Researchers, educators, students, and administrators work together in CAR or | The purpose of this research is to improve students' learning outcomes in chemistry subjects by using Problem-based learning model in class X students of SMAN 6 Mataram. This study |

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| | Problem-Based Learning Model for Class X Students at SMAN 6 Mataram" | | collaborative classroom action research. | used the method of Collaborative Classroom Action Research (PTK) which took place with three cycles, where each cycle included several steps, including planning, implementation, observation, and reflection. In this study, the subjects were students of class X6 SMAN 6 Mataram which amounted to 34 students. The results of the research obtained are Problem Based Learning learning model can improve students' cognitive learning outcomes in chemistry. This can be seen from the average value of students' cognitive learning outcomes and the percentage of classical learning completeness. The average value of students in the first cycle was 48.84 with a percentage of classical learning completeness of 20.50%, in cycle two the average value of students was 78.78 with a percentage of classical learning completeness of 88.2%, while in cycle three the average value of students was 87.66 with a percentage of classical learning completeness of 97%. This research is expected to form a new solution to solve problems in learning activities, especially in chemistry subjects. |
| 7 | "Improving Learning Outcomes and Critical Thinking Skills of Students with Problem-Based Learning Materials on Chemical Calculations" | (Cut Meutia, 2021) | This research is an example of classroom action research; it uses classroom assessment and observation to conclude the population of class X MIPA 5. | The study entitled Improving Learning Outcomes and Critical Thinking Skills of Students in Chemical Calculation Material Through the Problem Based Learning Learning Model, The purpose of the study was to determine how critical thinking skills and the completeness of learning outcomes in chemical calculation material in chemistry lessons using the Problem Based Learning learning model in class X MIPA 5 students of SMA Negeri 1 Banda Aceh, the nature of the research is classroom action research, the source of research data is all students of Class X MIPA 5, the collection tool is tests and observations, data analysis This analysis is |

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| | | | | carried out by calculating and describing data from test results and observations with the provisions Maximum score = highest score x number of questions x number of respondents, Minimum score = lowest score x number of questions x number of respondents, Score range = maximum score - minimum score and - Class interval = score range: 4. The results showed that there was an increase in the completeness of student learning outcomes from 43.78% pre-cycle increased to 57.79% in cycle I and in cycle II increased to 75.24%. |
| 8 | "Application of Problem-Based Learning Model and Culturally Responsive Teaching Approach to Optimize Chemistry Learning Outcomes" | (Wahyuningsih et al., 2023) | This research utilizes the Lesson Study model and classroom action research strategy. | The study entitled Improving Learning Outcomes and Students' Critical Thinking Skills in Chemical Calculation Material Through the Problem Based Learning Learning Model, The purpose of the study was to determine how critical thinking skills and the completeness of learning outcomes in chemical calculation material in chemistry lessons using the Problem Based Learning learning model in class X MIPA 5 students of SMA Negeri 1 Banda Aceh, the nature of the research is classroom action research, the source of research data is all students of Class X MIPA 5, the collection tools are tests and observations, data analysis This analysis is carried out by calculating and describing data from test results and observations with the provisions Maximum score = highest score x number of questions x number of respondents, Minimum score = lowest score x number of questions x number of respondents, Score range = maximum score - minimum score and - Class interval = score range: 4. The results showed that there was an increase in the completeness of student learning outcomes from 43.78% pre-cycle increased to 57.79% in cycle I |

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| | | | | and in cycle II increased to 75.24%. |
| 9 | "Application of Problem-Based Learning Model with Multimedia Support to Improve Chemistry Learning Activity and Student Assessment Results" | (Santi et al., 2021) | Classroom action research is known as CAR. | This research was conducted with the aim of describing the application of the Problem Based Learning (PBL) model with multimedia assistance to learning activities and student learning outcomes of class XII MIPA C SMA Negeri 6 Bengkulu City in the Faraday Law submission. This research was conducted in two cycles, with four stages, namely 1) planning, 2) implementation, 3) observation, and 4) reflection. Teachers and all students of class XII MIPA C SMA Negeri 6 Bengkulu City for the academic year 2020/2021 were the subjects in this study, which was conducted on November 19, 2020 to November 27, 2020. Based on the results of the research that has been carried out, increased teacher and student activity and results student learning increases with each cycle. Teacher activity has increased by an average of 23 in cycle I and increased to 25.5 in cycle II. The results of the average student activity in the first cycle was 20 and increased to 25 in the second cycle. Likewise with the student's cognitive learning outcomes, which also increased from the first cycle, namely 41.67 to 80.3 in the second cycle. It can be said that the application of the Problem Based Learning model with the assistance of multimedia in Faraday's Law submission is able to improve learning activities and student learning outcomes. |
| 10 | "Application of Problem-Based Learning Model with Culturally Responsive Teaching (CRT) to Improve Learning Outcomes and Student Motivation in Chemistry Class X | (Sari et al., 2023) | Classroom action research (CAR) was used in this study to collect data through daily records, learning outcomes, questionnaires, and | This study is a Classroom Action Research that aims to investigate whether the implementation of the Problem-Based Learning model integrated with Culturally Responsive Teaching (CRT) can enhance the motivation and learning outcomes of X IPA 2 at SMA Negeri 7 Mataram in the subject of Chemistry for the academic year 2022/2023. The |

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| | IPA 2 SMA Negeri 7 Mataram Study Year 2022-2023" | | observations. | research employs the Classroom Action Research method, consisting of planning, acting, observing, and reflecting. Data sources include both quantitative and qualitative data, encompassing pre-test and post-test results, observations of the teaching and learning process, questionnaire responses, daily journals/field notes, and activity photos. The research is conducted collaboratively with fellow teachers to assess student motivation and learning outcomes after implementing the intervention in two cycles, with each cycle comprising two sessions. The results of the study indicate that the application of the Problem-Based Learning model integrated with Culturally Responsive Teaching demonstrates high student motivation, with an agreement percentage of 89%. Additionally, there is an evident improvement in student engagement, as shown by an average class activity percentage of 60.96% in the first cycle and 87% in the second cycle. Furthermore, there is an enhancement in student learning outcomes, with a proficiency percentage increasing from 77% in the first cycle to 86% in the second cycle. |
| 11 | "Application of Problem-Based Learning (PBL) Model on Chemical Equilibrium Material of SMAN 3 Bengkulu City to Improve Student Activity and Learning Outcomes" | (Maulana et al., 2021) | The research in this study was organized as a three-cycle classroom action research (CAR). | The purpose of this study was to improve the activity and learning outcomes of students in chemical equilibrium material at SMA N 3 Kota Bengkulu. This study is a classroom action research (CAR) consisting of three cycles. This study was conducted in class XI MIPA 5. The instruments used were observation instruments and cognitive tests. Based on the results of observations from Cycle I, cycle II, and Cycle III, there was an increase in the percentage of student activity and student completion. Respectively, the percentage of student activity was 32.37%, 55.25%, and 84.76%. While the percentage of student learning |

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| | | | | completion was 17%, 31.4%, and 82.8%, respectively. The results showed that the application of the problem-based learning model succeeded in increasing student activity and learning outcomes. This can be seen from the percentage of activity and learning completion which has increased and is more than 75%. |
| 12 | "Application of Problem-Based Learning (PBL) in the Post-Pandemic Era to Improve Chemistry Learning Outcomes of Students in Class XI IPA 3 MAN Kapuas in the 2022-2023 Academic Year by Using Acid-Base Materials" | (Susanty, 2023) | Classroom action research (CAR) is the core of this study. | The research conducted was classroom action research on chemistry learning at MAN Kapuas which was carried out in the 2022/2023 academic year. The subjects of the study were students of class XI IPA 3 with a sample technique using total sampling. The study of improving chemistry learning outcomes used individual KKM achievement indicators with a minimum achievement value of 70 with a minimum completion of 85% classically. With the stages of achievement of each indicator in each cycle carried out in two cycles with the results of learning activities that had been carried out for two cycles, both from the results of observations and the results of evaluation of learning activities with the PBL method, an increase in learning completion was obtained from 69% to 92%, from learning outcomes there was also an increase in learning outcomes from an average value of 70.8 to 82.5, so it can be concluded that learning completion with the PBL learning method in post-pandemic learning for chemistry subjects, acid-base material was completed classically 92% with an average value of 82.5 has been successful. |
| 13 | "Application of Problem-Based Learning Model to Improve Cognitive Learning Outcomes of Chemistry Class X Students at SMK N 1 Danau Sembuluh | (Listiani, 2022) | Using a Classroom Action Research (CAR) approach, this study collected data through direct | This study is entitled The Application of the Problem-Based Learning Model to Improve Cognitive Learning Outcomes in Chemistry on the Material of basic chemical laws and the Concept of Moles of class X students of SMK N 1 Danau Sembuluh Seruyn Central |

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| | Seruyan Central Kalimantan 2020-2021 Study Year on Basic Law of Chemistry and Mole Concept" | | observation of how students learn in a classroom environment. Written exams and observational approaches were the means used to collect data. | Kalimantan in the 2020/2021 academic year (Online). The purpose of this study is to improve cognitive learning outcomes of students in chemistry learning the material of basic chemical laws and the concept of moles with the Problem-Based Learning model. This study is a Classroom Action Research (CAR) which uses direct observation data on the learning process in the classroom. The results of this study indicate that the application of the Problem-Based Learning model can improve students' cognitive learning outcomes with an average increase in student learning outcomes from cycle I 57.89, cycle II 69.47, and cycle III 81.05. Classical completeness also increased, in cycle I 52.63% in cycle II 73.68%, and in cycle II 89.47%. |
| 14 | "Application of Problem-Based Learning (PBL) Model on Differentiated Learning to Improve Students' Chemistry Learning Outcomes on Reaction Rate Material" | (Ashilah et al., 2023) | Classroom Action Research (CAR) is the working title of these two study sections. At the end of each semester, students are given a multiple-choice assessment exam to collect data on learning outcomes. | This study aims to determine the implementation of differentiated learning with the Problem-Based Learning (PBL) model in improving students' chemistry learning outcomes on the reaction rate material. This study also aims to determine the classical improvement of students' chemistry learning outcomes through the implementation of differentiated learning with the Problem-Based Learning (PBL) model on the reaction rate material. This Classroom Action Research was conducted in two cycles in class XII Chemistry L4 in the odd semester of the 2023/2024 academic year consisting of planning, action, observation, and reflection. Data collection of learning outcomes was carried out by giving an evaluation test at the end of the cycle in the form of a multiple-choice test and analyzed using descriptive quantitative analysis concerning the achievement of KKM per individual of 75 and classical learning completeness of at least |

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| | | | | 80%. After conducting descriptive statistical analysis, the classical completeness of students' learning outcomes was obtained from cycle I 75.76% to 90.10% in cycle II where there was an increase in learning outcomes of 14.34%. Thus, it can be concluded that the implementation of differentiated learning can improve students' learning outcomes on the chemical reaction rate material. |
| 15 | "Improving Activeness and Learning Outcomes of Redox and Electrochemistry Materials through Problem-Based Learning Models" | (Mulyati, 2021) | This study utilized a two-cycle paradigm for classroom action research using qualitative methodology. Motivational surveys were administered before the cycle, learning evaluations after cycles I and II, and questionnaires at the end of the cycle to collect data. | Chemistry is included in the interest group together with mathematics and other science subjects. For students who choose this interest and are less interested in studying chemistry, there is a compulsion to study it. They will have difficulty in understanding chemical concepts, especially in more complex concepts such as redox and electrochemistry. Based on mid-semester assessments in the last two years, the average score is 57 and learning achievement is 69% below the KKM and the average activity based on the questionnaire is below 60%. This study uses a classroom action research (CAR) method which aims to improve the quality of chemistry learning. This study uses two cycles. Each cycle includes the stages of planning, implementation, observation, and reflection. This study uses the Problem Based Learning Model on Redox and Electrochemistry materials. For learning achievements in cycle 1, only 18 students or 50% can achieve an average score of 68 and the average student activity in discussions is 60%. Students as many as 31 people or 86% obtained an average score of 84 and discussion activity became 74% in cycle 2. implemented at SMA Negeri 60 Jakarta with respondents being students of class XII MIPA 1 totaling 36 students consisting of 19 male students and 17 female students. In its implementation, educators |

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| | | | | were assisted by fellow educators who taught in class 11 and served as observers/observers during the learning process. |
| 16 | "Application of Problem-Based Learning (PBL) Learning Model in Chemistry Class X-6 SMA Negeri 4 Mataram to Improve Student Learning Outcomes" | (Baqiyatusshalihah et al., 2023) | This form of collaborative classroom action research (CAR) is based on the two-part technique proposed by Kemmis and Taggart. | Based on a pre-class action study at SMA Negeri 4 Mataram, the percentage of students in class X-6 who learned something was 2.86 percent in the less category, 68.75% in the sufficient category in cycle I, and 74.26% in the appropriate category in cycle I. The results showed that students in class X-6 at SMA Negeri 4 Mataram can achieve better learning outcomes if the problem-based learning paradigm is implemented in the chemistry classroom. The results showed that students in class X-6 at SMA Negeri 4 Mataram can achieve better learning outcomes if the problem-based learning paradigm is implemented in chemistry classrooms. |
| 17 | "Improving Students' Learning Outcomes On Chemical Bonding Material With The Problem Based Learning Model" | (Maimunah, 2022) | By combining multiple choice and non-test questions, PTK is a data collection approach. | One way to improve student learning outcomes for chemistry subjects, especially chemical bonding material is to use a problem based learning learning model, which is the problem formulation of this study whether by using a problem based learning learning model in chemistry subjects chemical bonding material is able to improve learning outcomes of class X IPA-2 SMA Negeri 1 Panga, Aceh Jaya Regency. The purpose of this study was to improve the learning outcomes of students of class X IPA-2 SMA Negeri 1 Panga, Aceh Jaya Regency in the subject of chemical bonding material. The benefit of this research is to improve student learning outcomes in chemistry subjects chemical bonding material. The subjects of this study were students of class X IPA-2 SMAN 1 Panga, Aceh Jaya Regency, 2021/2022 academic year, totaling 24 students, to obtain the author's data using test and non-test techniques. After the data is |

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| | | | | collected, the writer processes and analyzes the data by comparing the results of observations and tests in cycle I and cycle II. The results showed that there was an increase in student learning outcomes, from no students who passed (0%) in the pre-cycle to 12 students who passed (50%) in the first cycle and 20 students who passed (83%) in the second cycle. |
| 18 | "Application of Problem-Based Learning Model to Improve Electron Configuration Chemistry Learning Outcomes" | (Mustatiroh et al., 2023) | A classroom action research design was used for this study. After each learning step, data was collected through observation and analysis. The approach used was the Scientific-TPACK methodology. | One of the efforts to improve chemistry learning outcomes is the application of Problem Based Learning (PBL) model. To find out chemistry learning outcomes, classroom action research (CAR) is carried out by applying the Problem Based Learning model. The subjects of this study were 15 students of class X TBSM SMK Sore 1 Ponorogo. The implementation of this research was carried out in 3 (three) cycles. The KKM for Chemistry subjects for students is 70. The method used is discussion and with a Scientific-TPACK approach. Data collection was carried out using observation and evaluation techniques at the end of learning in each cycle. The results of this study indicate that the application of the Problem Based Learning model can improve student learning outcomes. In the first cycle the average score is 65 with 40% completeness, the average value in the second cycle increases to 76 with 73% completeness and in the third cycle the average value reaches 84 and completeness reaches 100%. |
| 19 | "Application of Online-Based Problem-Based Learning Approach to Improve Learning Outcomes of Basic Chemical Analysis on Solution Concentration of Class X TMI-2 Students of SMKN | (Khabibah, 2021) | Classroom action research was used to carry out this study. | Basic Chemical Analysis learning in class X TMI-2 SMKN 1 Duduksampeyan Gresik in the 2020/2021 academic year experienced many obstacles, especially in the reaction rate material. In the competency test, the average student score was very low, this is thought to be because learning only takes place in one direction. Students are not directly |

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| | 1 Duduksampeyan Gresik" | | | involved in the learning process and learning is carried out online, so teachers have difficulty in controlling student activity. The purpose of this study was to determine the effectiveness of the online problem-based learning approach on student learning achievement. Based on the results of the study, it was concluded that the problem-based learning approach is very effective in improving learning achievement in Basic Chemical Analysis regarding solution concentration. This can be seen from the increasing post-test results. In the first cycle, the average post-test result was 71.7. Students who had achieved learning completeness were 28 students or 77.8%. While students who had not achieved learning completeness were 8 students or 22.3%. In the second cycle, the average post-test result was 79.3 and classical learning completeness reached 88.9%. This shows that 32 out of 36 students have completed their studies. |
| 20 | "Improving Learning Outcomes and Self-Efficacy by Implementing a Problem-Based Learning Model on Electrolyte and Non-Electrolyte Solutions" | (Halnas et al., 2022) | This study used two iterations of classroom action research (CAR). | Has done research using problem based learning on electrolit and non-electrolit solution material. This research aim to increasing student self efficacy and learning outcomes on electrolit and non-electrolit solution material. This is a class action research with 2 cycle, which each cycle consist of planning, action, observation, and reflection step. Subject of research is student class X from SMKN 2 Banjarmasin department of computer and C network technique 2017/2018. Research instrument are test and nontest. Result of study shown that there are increasing amount of student self efficacy from cycle 1 to cycle 2 from passable category with a score 49,69 to 58,58 with good category, leaning outcomes cognitif aspect increase from 51,43% to 88,57%, student |

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| | atitude assesment shown a development from passable category with a score 6,325 to good category with a score 10,08. Student skill increase from enough skilled category with 51,04% to skilled with 71,04%, student respond on problem based learning categorized as good with a score 38,74 |

The findings of this study indicate that incorporating the PBL approach into chemistry learning can encourage students' participation in class discussions. The PBL approach has the potential to significantly affect students' critical thinking, collaboration, academic performance, learning outcomes, and their capacity to articulate their views.

According to the study, students' ability to make persuasive arguments is improved by PBL. Students are motivated to provide answers to the challenges presented, which aligns with the results of the study by Despita and Makmur et al. (2022). Students need to communicate and work together in groups to solve problems and then discuss how the problems are applied in real life. In conclusion, problem-based learning (PBL) will improve students' learning ability. The best teaching methods help students develop and hone the critical thinking, problem-solving, collaboration, and communication skills needed to succeed in the modern world. Effective classroom teaching provides ample opportunities to hone these skills. Skills in critical thinking, process description, and questioning are important components of the learning process. Their use in PBL classrooms has the potential to improve student achievement standards.

Students can be inspired, and their knowledge can be strengthened through problem-based learning strategies. Lumban Gaol (2020) and others have supported research findings showing how problem-based learning paradigms can improve student learning outcomes (Lumban Gaol, 2020). Several studies have shown that problem-based learning (Intan et al., 2023) improves student learning outcomes, instructor teaching, and student learning activities. Related studies have shown that problem-based learning affects students' capacity to solve challenging chemistry problems (Woa et al., 2020).

The findings from the evaluation indicate that chemistry course objectives can be enhanced through the use of problem-based learning strategies. The study demonstrated that students can engage in critical thinking and actively expand their knowledge through their interactions with the learning environment established by their instructor. Improving students' analytical, deductive, and inferential reasoning skills is a goal of the student-centered problem-based learning approach. Students gain many benefits from problem-based learning methods, such as improved concentration, increased ability to apply what they have learned in real-world settings, increased opportunities for group work, and a deeper understanding of the relevance of their learning.

## CONCLUSION AND RECOMMENDATION

### A. Conclusion

The results are consistent with a literature review linking problem-based learning (PBL) to better student performance in chemistry and other STEM courses. Students can improve their critical thinking skills, engage in meaningful group work and interpersonal interactions, develop an inner passion for learning, and increase their engagement with the material and involvement in class discussions by following a PBL approach. The study authors concluded that the PBL learning model can help students achieve their learning goals in chemistry classes and recommend it to other instructors. Use this PBL paradigm with as much preparation as possible if students can complete the learning steps.

### B. Recommendation

The Problem-Based Learning (PBL) model has been widely used in chemistry learning because it improves students' conceptual understanding and learning outcomes. Based on research results, the application of the PBL model in chemistry learning has been proven to improve student learning outcomes significantly. This is because the PBL model encourages students to be more active in finding and understanding concepts through solving problems that are relevant to real life. In addition, PBL also improves critical and collaborative thinking skills, which contribute to a deeper understanding of the material. Therefore, further research can be

conducted to explore the effectiveness of PBL in various chemistry subtopics and examine factors that can optimize its application in the classroom.

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