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Research Trends in the Application of Problem Based Learning Model in chemistry learning in Indonesia: A Systematic Literature Review

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ABSTRACT: This study aims to analyze and map research trends on the application of the Problem-Based Learning (PBL) model in chemistry education in Indonesia using the systematic literature review (SLR) method. The study involved secondary data sourced from the SINTA database for publications between 2015 and 2024. Articles were identified using the keywords "problem-based learning" and "chemistry", with inclusion criteria comprising: (1) studies implementing PBL in chemistry learning, (2) published between 2015 and 2024, (3) document type limited to peer-reviewed articles, and (4) articles indexed at least by Sinta 3. Out of an initial 182 articles retrieved, only 21 articles met the inclusion criteria after screening. The results indicate the PBL model has been implemented using various approaches, strategies, and media, demonstrating its effectiveness in improving students' learning outcomes, critical thinking skills, and engagement in chemistry education. The most frequent research focus was on learning outcomes, followed by learning activities and critical thinking skills, while other variables such as scientific attitudes, self-efficacy, and collaboration also received attention. PBL's adaptability, including integration with STEM and digital media, enhances its relevance to modern learning demands. This study highlights the significant role of PBL in fostering student-centered learning and bridging theoretical and practical aspects of chemistry. Limitations in database scope and inclusion criteria highlight the need for broader reviews. Future studies should include meta-analyses and explore interdisciplinary applications to enhance PBL's potential in chemistry education. These findings offer valuable insights for educators and researchers aiming to optimize PBL in Indonesian education

Keywords: Problem Based Learning, Chemistry, Indonesia, Systematic Literature Review

INTRODUCTION

Chemistry is learning that has many abstract and very complex material concepts, making many students have difficulty in understanding chemistry concepts and making students become misconceptions in chemistry material [1]. Chemistry generally includes abstract concepts that make many students fail in learning chemistry [2].

Problem-based learning can be used as an alternative in overcoming students' problems in understanding chemistry concepts [3]. Problem-based learning is a learning model that concepts and skills of students through complex real-world problems and solutions to overcome them through theories, concepts and facts provided by a teacher [4] and problem-based learning can overcome misconceptions in chemistry [5]. Literature research on problem-based learning has been conducted for several years [5]. Early studies often focused on the design and implementation of problem-based learning strategies [6, 7]. Later, research expanded to the assessment of problem-based learning outcomes [8], and in 2022, the evolution of problem-based learning was discussed [9].

From the description above, it is evident that many studies have applied the problem-based learning model using various research methods. However, the object of research and research materials used

must be different, so researchers are interested in conducting research with the systematic literature review method by collecting various previous articles that have relevance to the topic of this research to prove scientifically that the success of the problem base learning model has a good influence in teaching and learning activities of chemistry subjects in the classroom.

This systematic literature review article presents the results of a review of several articles that focus on learning chemistry using the problem base learning model. The articles reviewed in this study are from 2014 to 2024. Through the systematic literature review, it is hoped that researchers and chemistry teachers will get references and information related to the application of problem base learning models in chemistry learning.

RESEARCH METHODS

Research Design

This study employs a systematic literature review (SLR) design, which aims to identify, evaluate, and synthesize research articles systematically. The SLR is designed to integrate findings from various studies to address research questions in a structured manner [10]. In this study, the SLR method was used to analyze the application of problem-based learning (PBL) strategy in chemistry education within a specific timeframe, covering publications from 2015 to 2024.

The search strategy was conducted using the SINTA database as the primary source, which is a key repository for Indonesian academic literature. The search process involved the use of keywords such as 'problem-based learning' and 'chemistry,' which were applied to titles, abstracts, and keywords in the database. An initial total of 182 articles was retrieved based on these search terms. These articles were then screened to ensure they met the inclusion criteria for relevance to the research topic. The decision to limit the search to the SINTA database was made to focus on research conducted within Indonesia, which provides valuable context for understanding the local application and development of problem-based learning in chemistry.

Data Analysis and Study Selection Criteria

The inclusion criteria used in this research were as follows: (1) the articles must apply problem-based learning in the context of chemistry education, either in schools or universities; (2) the articles must have been published between 2015 and 2024; (3) the document type must be peer-reviewed journal articles; and (4) the articles must be indexed by Sinta 3 or higher. Following the screening process, 161 articles were excluded for not meeting the inclusion criteria. As a result, a total of 21 articles were selected for further analysis. The results of article selection in this study can be seen in Figure 1.

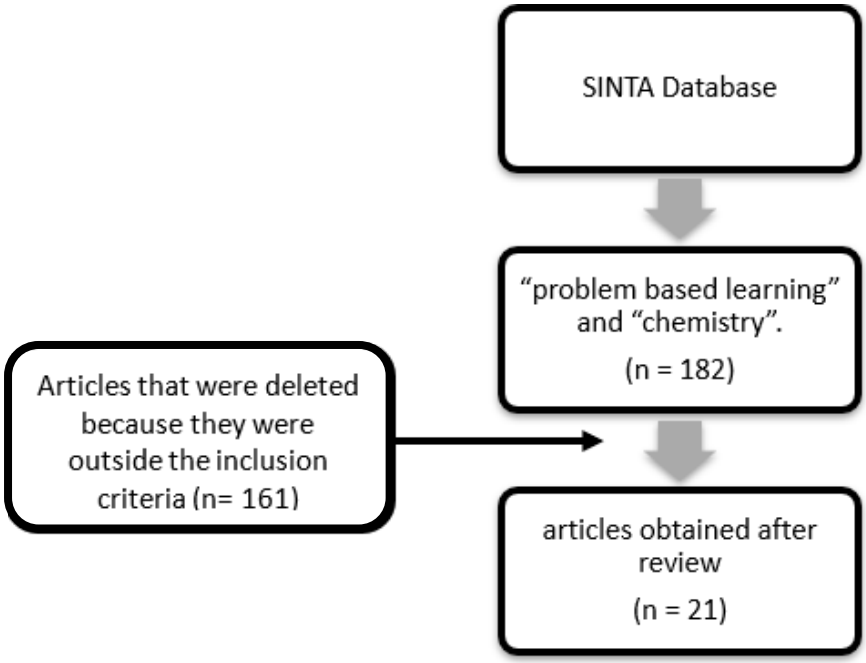

FIGURE 1. Article Search Stage

In the data analysis stage, the selected articles were reviewed in detail to identify their contributions to the research objectives. The analysis focused on various aspects of applying problem-based learning in chemistry education, such as its impact on student learning outcomes, critical thinking skills, student engagement, and the development of scientific attitudes. These findings were summarized and organized as a list in Table 1, which includes the authors, research titles, and the main focus of each study. The analyzed articles provide a deeper understanding of how problem-based learning contributes to chemistry education and how this model enhances various student skills.

TABLE 1. Article Search Results

No	Research Title	References
1	Pengaruh Model Mengajar Menginduksi Perubahan Konsep Simson Tarigan dan Problem Based Learning dengan Media Ms Frontpage Terhadap Kemampuan Berpikir Kritis dan Hasil Belajar Kimia	[11]
2	Penerapan Model Problem Based Learning Menggunakan Media Exe Learning untuk Meningkatkan Hasil Belajar dan Kerjasama Siswa Pada Materi Hidrokarbon	[12]
3	The Application of Problem Based Learning Model Integrated Guided Inquiry Model Using Computer Based Media on Salt Hydrolysis Learning for High School Students Improve Learning Outcomes Class XI Science In Medan	[13]
4	The Effect of E-Learning Media Application Using Problem Based Learning Models to Activities and Results of Student Learning in Salt Hydrolysis Subject	[14]
5	The Difference of Student's Activities and Learning Outcome with Problem Based Learning Using Macromedia Flash and Handout	[15]
6	The Effectiveness of Argumentation Based Learning And Problem Based Learning Models in Improving Student's Argumentation Skills About Salt Hydrolysis Concept	[16]
7	Peningkatan Keterampilan Memecahkan Masalah Melalui Model Pembelajaran Problem Based Learning (PBL) Pada Mata Pelajaran Kimia	[17]
8	Peningkatan Efikasi Diri Siswa Pada Materi Kesetimbangan Kimia Setelah Dibelajarkan Dengan Problem Solving Berbasis Multiple Representasi	[18]
9	Peningkatan Efikasi Diri Siswa Pada Materi Kesetimbangan Kimia Setelah Dibelajarkan Dengan Problem Solving Berbasis Multiple Representasi	[19]
10	The Effectiveness of Problem Based Learning Model to Improve Students' Science Process Skills	[20]
11	Pengaruh Model Problem Based Learning Terhadap Hasil Belajar Dan Keterampilan Proses Sains	[21]
12	Analisis Berpikir Kreatif Pada Penerapan Problem Based Learning Berpendekatan Science, Technology, Engineering, and Mathematics	[22]
13	Problem Based Learning (PBL) Pada Topik Struktur Atom: Keaktifan, Kreativitas Dan Prestasi Belajar Siswa	[23]
14	Penerapan Model Pembelajaran Problem-Based Learning terhadap Kemampuan Berpikir Kritis dan Aktivitas Belajar Peserta Didik pada Materi Hidrolisis Garam	[24]
15	Pengaruh Penggunaan Model Pembelajaran Problem Based Learning (Pbl)-Study History Sheet (Shs) Bahan Ajar Berbasis Green Chemistry Pada Materi Kelarutan Dan Hasil Kali Kelarutan Terhadap Prestasi Belajar Belajar Siswa Kelas Xi Sma Negeri 10 Malang	[25]
16	Perbandingan Hasil Belajar Menggunakan Model Problem Based Learning Dan Think Pair Share Pada Materi Sistem Koloid	[26]
17	Perbandingan Hasil Belajar Kimia Siswa Dengan Model Problem Based Learning Dan Think Pair Share Pada Materi Kelarutan Dan Hasil Kali Kelarutan	[27]

No	Research Title	References
18	The Influence of Problem Based Learning Models on Cognitive Learning Outcomes and Scientific Attitudes of High School Students on Thermochemical Subject	[28]
19	The Effect of Problem-Based Learning on Students' Self-Regulated Learning of Chemistry Learning	[29]
20	Pengaruh Pembelajaran Berbasis Masalah Terhadap Minat Belajar Kimia Peserta Didik	[30]
21	Improving Student Activities and Learning Outcomes Through the Problem-Based Learning Model In Chemistry Learning	[31]

RESULT AND DISCUSSION

The Problem-Based Learning (PBL) model has become a widely adopted pedagogical approach in Indonesian chemistry education, with numerous studies highlighting its effectiveness in improving students' critical thinking, problem-solving skills, and conceptual understanding [32, 33]. Research trends indicate a growing application of PBL across both secondary and higher education, where its positive impact on student engagement and learning outcomes is frequently observed. However, challenges such as the need for teacher training and curriculum adaptation continue to be barriers in some contexts.

Future research should focus on addressing these challenges while exploring the integration of digital tools with PBL to further enhance learning experiences. Additionally, investigating the adaptation of PBL for diverse student populations and its long-term impact on learning will provide valuable insights into optimizing its implementation in Indonesian chemistry education.

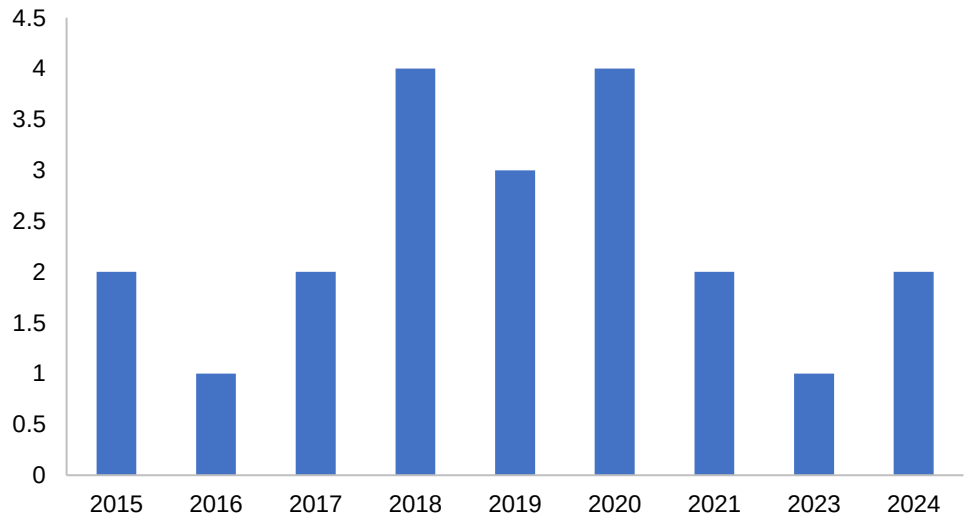

FIGURE 2. Number of Problem Based Learning Publications

Based on this research, the number of publications that appear in a certain period of time shows how often researchers conduct research on chemistry learning using the Problem-Based Learning Approach. Figure 2 shows that there is an increasing trend of PBL research from 2015 to 2024.

Based on Figure 2, from the frequency data of Problem Based Learning (PBL) research in chemistry learning from 2015 to 2024, there are significant fluctuations. The years with the largest number of publications are 2018 and 2020, each with 4 studies. However, after 2020, the frequency of research decreased, reaching its lowest point in 2023 with only 1 study. In 2024, the frequency increased again to 2 studies. This trend shows a changing interest in Problem based learning in chemistry, with clear periods of peak and decline.

Figure 2 shows that the data on the distribution of SINTA indexed articles in the following studies. Based on Figure 3, we investigated the publication patterns of articles in several education and chemistry-related journals by using the frequency data provided by SINTA. Our findings show significant

variations in publication productivity between the observed journals. The Journal of Chemical Education (JPKIM) was dominant as the most productive with 6 articles published, indicating a strong focus in scientific contributions. On the other hand, some other journals such as Journal of Science Education Research, Journal of Educational Chemistry, Journal of Chemical Learning, and Journal of Science Research, only published one article each, indicating a lower level of productivity.

Data on campus productivity in writing articles on the application of the Problem Based Learning (PBL) model in learning chemistry in high school shows that Semarang State University has the highest number of publications with four articles. Medan State University and Yogyakarta State University each contributed three publications, indicating active involvement in PBL model research.

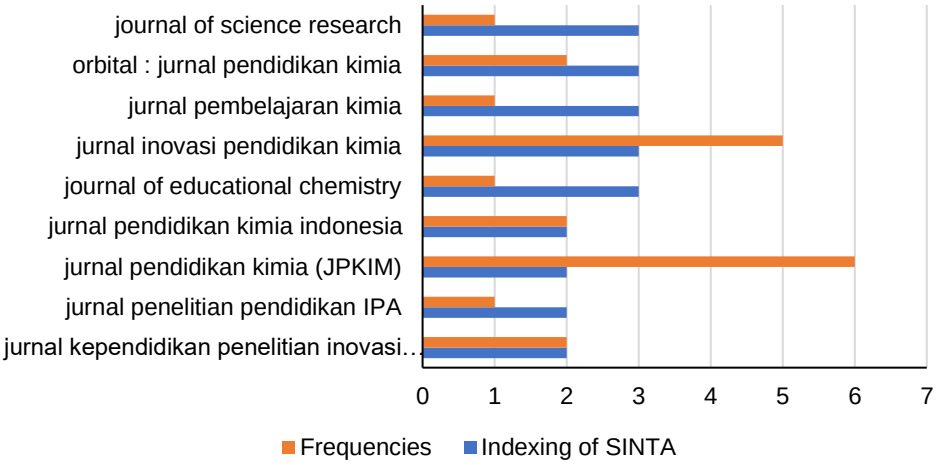

FIGURE 3. Distribution of SINTA Indexed Articles

Then the researchers analyzed campus productivity in writing articles on the application of problem-based learning models in chemistry learning at school. This can be seen in Figure 4.

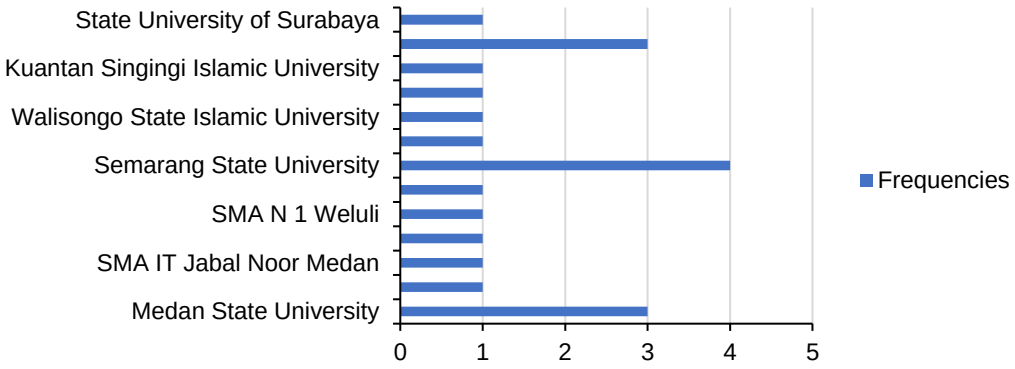

FIGURE 4. Campus productivity in researching problem-based learning

Other institutions such as Cut Meutia Technical Academy, Jabal Noor Medan IT High School, Jambi University, SMA N 1 Weluli, University of Flores, Sultan Ageng Tirtayasa University, Walisongo State Islamic University, Raden Fattah Islamic University, Kuantan Singingi Islamic University, and Surabaya State University each contributed one publication, showing an even interest in the application of the PBL model in various institutions.

This research highlights the increased interest of public universities in Indonesia in innovative learning models such as Problem Based Learning (PBL). The implementation of PBL is in line with the Merdeka Curriculum, which encourages the use of PBL to improve students' critical thinking and problem-solving skills and learning outcomes [35]. Geographical analysis of the data showed that

interest in PBL in chemistry education learning was considered relevant throughout Indonesia. In addition, the active participation of researchers from high school teachers indicates that there is co-operation between higher education institutions in implementing and evaluating PBL in chemistry learning [36]. This confirms the importance of PBL in wider education in Indonesia, as well as its relevance in achieving the objectives of the Merdeka Curriculum.

Furthermore, the researchers analysed the impact of the application of problem-based learning model in chemistry learning at school. This can be seen in Figure 5.

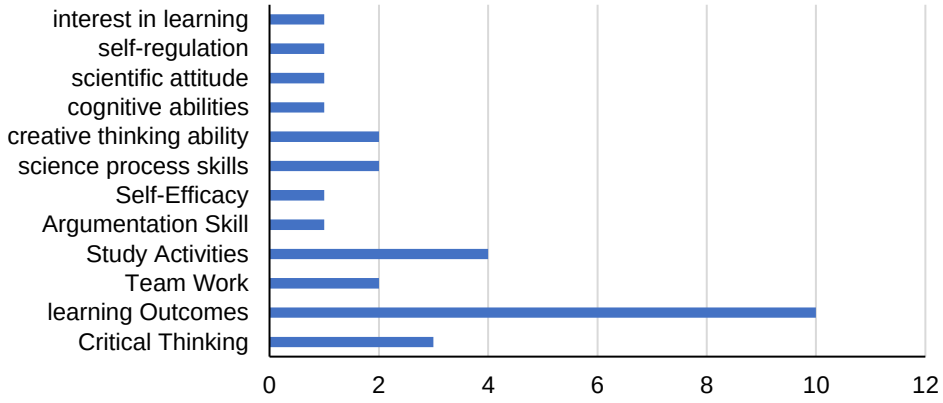

FIGURE 5. research variables used in problem-based learning

Based on the frequency data of research variables, learning outcomes were found to be the dominant focus in the application of the Problem-Based Learning (PBL) model in high school chemistry education, with the highest frequency of attention. This is expected, as learning outcomes are a key measure of any educational approach. However, the emphasis in PBL was not just on achieving basic knowledge but also on distinguishing between core or procedural knowledge and the development of soft skills. Specifically, PBL's potential to enhance students' understanding of chemical concepts through problem-solving and active participation was highlighted. Learning activities and critical thinking skills were also recorded as high priorities, emphasizing the importance of student engagement in both investigating subject matter and developing analytical abilities. In addition, other variables such as creative thinking, scientific process skills, cooperation, and psychological aspects like cognitive ability, learning interest, independence, scientific attitude, and self-efficacy were found to be relevant to the success of PBL. These findings underscore the importance of PBL in fostering not only conceptual knowledge but also the development of students' cognitive and affective skills in chemistry learning.

The application of Problem-Based Learning (PBL) in chemistry learning is proven to contribute significantly to various aspects of student learning [37]. Research covering variables such as frequency of critical thinking, learning outcomes, learning activities, and science process skills shows that PBL is able to improve the understanding of chemical concepts in depth. Students involved in PBL not only experience significant improvement in learning outcomes, but are also active in various activities such as experiments, discussions, and data analysis, which help them link theory with practice. In addition, PBL encourages collaboration between students in solving complex problems, strengthens argumentation skills based on scientific evidence, and develops scientific attitudes and learning independence.

TABLE 2. Results of Variation of Problem Based Learning Model in Chemistry Learning

No	Learning Model Variations	Research Output	References
1	Problem-based learning with the help of Ms Frontpage media	PBL learning using Ms Frontpage has a significant effect on students' critical thinking skills. In addition, the use of this method also has a significant impact on student learning outcomes.	[11]

No	Learning Model Variations	Research Output	References
2	Learning using problem-based learning model with computer media	There is a significant difference in learning outcomes between students taught with Direct Instruction and Problem-Based Learning models integrated using computer media. In the experimental model, learning places students as the centre of activity, where students actively discover, do, observe, and experience learning activities.	[13]
3	Problem-based learning with macromedia flash media and handouts	There is a difference in the activity and learning outcomes of students using PBL with Macromedia Flash and handouts on solubility of product constants. In addition, there is a positive correlation between student activity and learning outcomes with PBL using Macromedia Flash and handouts on the topic of product constant solubility.	[15]
4	Multiple representation problem-based learning	Students' self-efficacy differs significantly between those taught using a multiple representation-based problem-solving learning model and those taught using a conventional problem-solving model.	[18]
5	STEM integrated problem-based learning	The STEM-integrated problem-based learning (PBL) model can improve students' critical thinking skills, as shown by the N-gain and t-test results. The independent sample t-test showed a significant difference between the critical thinking skills of the control and experimental groups, while the paired sample t-test suggested that the STEM-integrated PBL model has a positive impact on students' critical thinking skills. This model can be applied in chemistry learning for learning innovation and is expected to improve students' critical thinking skills.	[19]
6	STEM integrated problem-based learning	The results showed that the average creative thinking ability of students reached good criteria with a score of 47.84 out of a total of 60, with the highest achievement in the indicator of viewing information from different points of view (89.48%). Students also gave positive responses to the learning process. In conclusion, after applying the STEM-based Problem-Based Learning model on KSP material, students' creative thinking skills are in good criteria.	[22]
7	Green chemistry problem-based learning (PBL)-based student worksheets (LKS)	The PBL-SHS model based on Green Chemistry improved the cognitive learning achievement of students in class XI SMA Negeri 10 Malang, with an average score of 79 in the experimental class and 76 in the control class. In addition, this model also improves affective achievement, with a percentage of student concern of 90% in the control class and 92% in the experimental class.	[25]

The results of the various studies listed show that the application of Problem-Based Learning (PBL) with various media, approaches, and strategies in learning provides positive results on students' learning abilities and achievements. In general, PBL is proven to be effective in improving students'

critical and creative thinking skills. For example, a study that used PBL with Ms Frontpage media [11] and Macromedia Flash and handouts [15] showed significant improvements in students' activities and learning outcomes on the topics studied. In addition, PBL integrated with computer media [13] and multiple representations [18] It also produces significant differences in student learning outcomes compared to traditional learning methods. This approach allows students to be actively involved in solving problems, observing and discovering new concepts independently. Furthermore, STEM-based PBL, PBL-SHS [19, 22] are also proven to have a positive impact on students' critical and creative thinking skills, as shown by the N-gain results and improvements in concept understanding in depth. Research related to PBL-SHS based on Green Chemistry. Subandi [25] shows that this model not only improves students' cognitive learning achievement, but also affective aspects such as concern for the environment. This indicates that the PBL approach can stimulate students' interest in the subject matter being taught.

These results show that PBL is an effective approach in improving the quality of learning by actively involving students in the learning process. The integration of various media, approaches and strategies in PBL provides flexibility and opportunities for students to optimally develop their critical, creative and collaborative thinking skills. Therefore, PBL can be used as one of the potential learning innovations to be applied in the context of sustainable and adaptive education.

CONCLUSION

The results of the literature review by analysing research trends on problem-based learning models are one of the most studied research topics from 2015 to 2024. In general, this research identifies the impact of the application of problem-based learning models that can improve various abilities and skills of students in learning chemistry. besides the problem-based learning model is a learning model that can be integrated with various media, strategies and other approaches to support chemistry learning outcomes. These findings emphasise the importance of using the Problem Based Learning (PBL) learning model in chemistry learning. Teachers need to study PBL more deeply to improve students' abilities and prepare themselves to integrate this model with various learning media and strategies. In addition, the study highlights the need for adequate teacher training in implementing PBL effectively, as well as the importance of interdisciplinary collaboration to develop innovative PBL approaches in line with modern learning demands. This study has several limitations. It relied solely on the SINTA database, excluding broader sources like Scopus or Web of Science, which may limit the scope of the review. Future research should expand the databases used, such as including Scopus or Web of Science, and employ a broader range of keywords to capture more comprehensive data. Adjusting the inclusion criteria to allow credible studies outside Sinta 3 and using automated tools for screening could reduce bias. Incorporating meta-analysis in future reviews would provide stronger statistical evidence on the effectiveness of problem-based learning in chemistry education. The use of specific keywords ("problem-based learning" and "chemistry") might also originated missing studies with synonymous terms. Strict inclusion criteria, such as requiring articles to be indexed in Sinta 3 or higher, may exclude relevant studies. Additionally, manual screening of articles introduces potential bias, and the absence of meta-analysis limits the statistical depth of the findings.

REFERENCES

[1] D. D. Milenković, M. D. Segedinac, dan T. N. Hrin, “Increasing high school students’ chemistry performance and reducing cognitive load through an instructional strategy based on the interaction of multiple levels of knowledge representation,” *J. Chem. Educ.*, vol. 91, no. 9, p. 1409–1416, 2014, doi: 10.1021/ed400805p.

[2] M. B. Nakhleh, “Why some students don’t learn chemistry: Chemical misconceptions,” *J. Chem. Educ.*, vol. 69, no. 3, hlm. 191–196, 1992, doi: 10.1021/ed069p191.

[3] A. Purwanto, “Socio-critical and problem-oriented approach in environmental issues for students ’ critical thinking,” *J. Technol. Sci. Educ.*, vol. 12, no. 1, hlm. 50–67, 2022, doi: 10.3926/jotse.1341.

[4] H. S. Barrows dan R. M. Tamblyn, *Problem-based learning: An approach to medical education*, vol. 1. Springer Publishing Company, 1980.

[5] H. G. Seyhan dan G. E. Türk, “The Effect of Argumentation-Supported Problem-Based Learning Method in Teaching Chemical Equilibrium and Le-Chatelier’s Principle,” *Mimb. Sekol. Dasar*, vol. 9, no. 3, hlm. 413–430, 2022, doi: 10.53400/mimbar-sd.v9i3.45585.

[6] H. G. Norman, G. T., & Schmidt, "The psychological basis of problem-based learning: A review of the evidence. Academic Medicine," 1992, *Academic Medicine,*.
[7] M. A. Albanese dan S. Mitchell, "Problem-based learning: A review of literature on its outcomes and implementation issues," *Acad. Med.*, vol. 68, no. 1, hlm. 52–81, 1993, doi: 10.1097/00001888-199301000-00012.
[8] G. C. H. Koh, H. E. Khoo, M. L. Wong, dan D. Koh, "The effects of problem-based learning during medical school on physician competency: A systematic review," *CMAJ Can. Med. Assoc. J.*, vol. 178, no. 1, hlm. 34–41, 2008, doi: 10.1503/cmaj.070565.
[9] P. Hallinger, "Tracking the Evolution of the Knowledge Base on Problem-based Learning: A Bibliometric Review, 1972-2019," *Interdiscip. J. Probl.-Based Learn.*, vol. 15, no. 1, 2021, doi: 10.14434/ijpbl.v15i1.28984.
[10] Y. Xiao dan M. Watson, "Guidance on Conducting a Systematic Literature Review," *J. Plan. Educ. Res.*, vol. 39, no. 1, hlm. 93–112, 2019, doi: 10.1177/0739456X17723971.
[11] N. Vayuni, S. Tarigan, dan D. Suyatni, "Pengaruh Model Mengajar Menginduksi Perubahan Konsep Simson Tarigan dan Problem Based Learning dengan Media Ms Frontpage Terhadap Kemampuan Berpikir Kritis dan Hasil Belajar Kimia," *Jurnal Pendidikan Kimia (JPKIM)*, vol. 7, no. 3, hlm. 53–61, 2015, doi: 10.24114/jpkim.v7i3.4258.
[12] I. S. Jahro dan D. Ridho, "Penerapan Model Problem Based Learning Menggunakan Media Exe Learning untuk Meningkatkan Hasil Belajar dan Kerjasama Siswa Pada Materi Hidrokarbon," *J. Pendidik. Kim.*, vol. 7, no. 3, hlm. 80–86, 2015, doi: 10.24114/jpkim.v7i3.4261.
[13] E. Fadillah, R. Silaban, dan I. S. Jahro, "The Application of Problem Based Learning Model Integrated Guided Inqury Model Using Computer Based Media on Salt Hydrolysis Learning for High School Students Improve Learning Outcomes Class XI Science in Medan," *J. Pendidik. Kim.*, vol. 8, no. 3, hlm. 213–219, 2016, doi: 10.24114/jpkim.v8i3.4921.
[14] N. Humairah, M. Damanik, dan E. Eddyanto, "The effect of e-learning media application using problem based learning models to activities and results of student learning in salt hydrolysis subject," *J. Pendidik. Kim.*, vol. 10, no. 3, hlm. 397–402, Des 2018, doi: 10.24114/jpkim.v10i3.12702.
[15] D. N. Purba, M. Damanik, S. Silaban, dan L. Simatupang, "The difference of student's activities and learning outcome with problem based learning using macromedia flash and handout," *J. Pendidik. Kim.*, vol. 10, no. 3, hlm. 403–408, Des 2018, doi: 10.24114/jpkim.v10i3.12704.
[16] A. P. Sari, H. Harizon, dan M. H. Effendi-Hasibuan, "The effectiveness of argumentation based learning and problem based learning models in improving student's argumentation skills about salt hydrolysis concept," *J. Pendidik. Kim.*, vol. 13, no. 3, hlm. 230–240, Des 2021, doi: 10.24114/jpkim.v13i3.29928.
[17] M. G. Jayadiningrat dan E. K. Ati, "Peningkatan Keterampilan Memecahkan Masalah Melalui Model Pembelajaran Problem Based Learning (Pbl) Pada Mata Pelajaran Kimia," *J. Pendidik. Kim. Indones.*, vol. 2, no. 1, hlm. 1, 2018, doi: 10.23887/jpk.v2i1.14133.
[18] M. T. Tima dan H. Sutrisno, "Pengaruh Pembelajaran Pemecahan Masalah Berbasis Representasi Multipel Pada Materi Kesetimbangan Kimia Terhadap Efikasi Diri Siswa," *J. Pendidik. Kim. Indones.*, vol. 4, no. 2, hlm. 70–77, 2020, doi: 10.23887/jpk.v4i2.21896.
[19] A. Ariyatun dan D. F. Octavianelis, "Pengaruh Model Problem Based Learning Terintegrasi Stem Terhadap Kemampuan Berpikir Kritis Siswa," *JEC J. Educ. Chem.*, vol. 2, no. 1, hlm. 33, 2020, doi: 10.21580/jec.2020.2.1.5434.
[20] P. C. Hardiyanti dan S. Wardani dan Sri Nurhayati, "Keefektifan Model Problem Based Learning Untuk Meningkatkan Keterampilan Proses Sains Siswa," *J. Inov. Pendidik. Kim.*, vol. 11, no. 1, hlm. 1862–1671, 2017, doi: 10.15294/jipk.v11i1.9714.
[21] M. C. Janah, A. T. Widodo, dan D. Kasmui, "Pengaruh Model Problem Based Learning Terhadap Hasil Belajar Dan Keterampilan Proses Sains," *J. Inov. Pendidik. Kim.*, vol. 12, no. 1, hlm. 2097–2107, 2018, doi: 10.15294/jipk.v12i1.13301.
[22] L. Arian, Sudarmin, dan S. Nurhayati, "Analisis Berpikir Kreatif Pada Penerapan Problem Based Learning Berpendekatan Science, Technology, Engineering, and Mathematics," *J. Inov. Pendidik. Kim.*, vol. 13, no. 1, hlm. 2307–2317, 2019, doi: 10.15294/jipk.v13i1.15159.
[23] I. Langitasari, T. Rogayah, dan S. Solfarina, "Problem Based Learning (Pbl) Pada Topik Struktur Atom : Keaktifan, Kreativitas Dan Prestasi Belajar Siswa," *J. Inov. Pendidik. Kim.*, vol. 15, no. 2, hlm. 2813–2823, 2021, doi: 10.15294/jipk.v15i2.24866.

[24] M. Zahro dan U. Lutfianasari, "Penerapan Model Pembelajaran Problem-Based Learning terhadap Kemampuan Berpikir Kritis dan Aktivitas Belajar Peserta Didik pada Materi Hidrolisis Garam," *J. Inov. Pendidik. Kim.*, vol. 18, no. 1, hlm. 17–22, 2024, doi: 10.15294/jipk.v18i1.45567.
[25] E. Subandi, R. Joharmawan, dan A. Santoso, "Pengaruh Penggunaan Model Pembelajaran Problem Based Learning (Pbl)-Study History Sheet (Shs) Bahan Ajar Berbasis Green Chemistry Pada Materi Kelarutan Dan Hasil Kali Kelarutan Terhadap Prestasi Belajar Belajar Siswa Kelas Xi Sma Negeri 10 Malang," *J-PEK J. Pembelajaran Kim.*, vol. 2, no. 2, hlm. 41–49, 2017, doi: 10.17977/um026v2i22017p041.
[26] H. Karmila, A. Amilda, dan E. Jayanti, "Perbandingan Hasil Belajar Menggunakan Model Problem Based Learning Dan Think Pair Share Pada Materi Sistem Koloid," *Orbital J. Pendidik. Kim.*, vol. 4, no. 1, hlm. 75–87, 2020, doi: 10.19109/ojpk.v4i1.5506.
[27] G. Wira, N. Yuhelman, dan J. Rahayuningsih, "Perbandingan Hasil Belajar Kimia Siswa Dengan Model Problem Based Learning Dan Think Pair Share Pada Materi Kelarutan Dan Hasil Kali Kelarutan Orbital : Jurnal Pendidikan Kimia," *J. Pendidik. Kim.*, vol. 3, no. 2, hlm. 167–176, 2019, doi: 10.19109/ojpk.v3i2.4903 .
[28] N. Adisha dan E. Rohaeti, "The Influence of Problem Based Learning Models on Cognitive Learning Outcomes and Scientific Attitudes of High School Students on Thermochemical Subject," *J. Penelit. Pendidik. IPA*, vol. 10, no. 4, hlm. 2136–2143, 2024, doi: 10.29303/jppipa.v10i4.6448.
[29] Suyanta, E. W. Laksono, N. F. Fadhilah, dan and Ihwan Rizky, "The Effect Of Problem-Based Learning On Students' Self-Regulated Learning Of Chemistry Learning," *J. Kependidikan Penelit. Inov. Pembelajaran*, Des 2019, doi: 10.21831/jk.v3i2.19695.
[30] W. P. Surya. dan I. S. Arty, "Pengaruh Pembelajaran Berbasis Masalah Terhadap Minat Belajar Kimia Peserta Didik," *J. Kependidikan Penelit. Inov. Pembelajaran*, vol. 4, no. 2, hlm. 1–5, 2020, doi: 10.21831/jk.v4i2.30543.
[31] P. C. Dini, R. Hidayah, dan S. Nurlatifah, "Improving Student Activities and Learning Outcomes through the Problem-Based Learning Model in Chemistry Learning," *J. Sci. Educ. Res.*, vol. 7, no. 2, hlm. 93–99, Sep 2023, doi: 10.21831/jser.v7i2.63343.
[32] M. Hafizah, S. Solin, C. T. Purba, M. M. Sihotang, R. Rahmad, dan M. A. Wirda, "Meta-Analysis: The Impact of Problem-Based Learning (PBL) Models on Students' Critical Thinking Skills," *J. Digit. Learn. Educ.*, vol. 4, no. 3, hlm. 167–179, 2024, doi: 10.52562/jdle.v4i3.1393.
[33] M. Arsyad, S. Guna, and S. Barus, "Enhancing Chemistry Education through Problem-Based Learning: Analyzing Student Engagement, Motivation, and Critical Thinking", *Curriculum*, vol. 2, no. 3, pp. 110–117, Jul. 2024, doi: 10.35335/curriculum.v2i3.178.
[34] M. H. A. Shiddiqi dan N. A. Setiyawan, "Implementation of A Problem-Based Learning Model with the Help of Interactive Presentation Media from Quizziz in Increasing Student Learning Motivation in Class XI MIPA 4 in Chemistry Learning at Kebakkramat State Senior High School," *Int. J. Chem. Educ. Res.*, hlm. 121–127, 2024, doi: 10.20885/ijcer.vol8.iss2.art5.
[35] N. M. J. Lembayung, O. Pahdianti, dan R. Jannah, "Peningkatan Hasil Belajar Siswa Pada Pembelajaran Kimia Melalui Penerapan Model Problem Based Learning Pada Siswa Kelas X Di Sman 6 Mataram," *J. Asimilasi Pendidik.*, vol. 1, no. 2, hlm. 82–86, 2023, doi: 10.61924/jasmin.v1i2.13.
[36] S. A. Adah, "Effect of Problem-Based Learning on Acquisition of Creative Thinking Skills among Chemistry Students in Ogoja Education Zone, Cross River State, Nigeria," *Int. J. Educ. Eval.*, vol. 8, no. 7, 2023, doi: 10.56201/ijee.v8.no7.2022.pg1.10 .
[37] B. Aidoo, S. K. Boateng, P. S. Kissi, dan I. Ofori, "Effect of Problem-Based Learning on Students' Achievement in Chemistry," *J. Educ. Pract.*, vol. 7, no. 33, hlm. 103–108, 2016. [Online] Available: https://iiste.org/Journals/index.php/JEP/article/view/34135.