

## PROBLEM-BASED LEARNING INTEGRATED DEEP LEARNING TO ENHANCE CRITICAL THINKING IN CHEMISTRY EDUCATION: A SYSTEMATIC REVIEW

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**Abstract:** Critical thinking becomes an important skill for students to face 21st-century global challenges. This urgent need prompted a change in the curriculum to Emancipated Curriculum (*Kurikulum Merdeka*), which has been further refined through a deep learning approach with three basic principles: Mindful, Meaningful, and Joyful Learning. The learning method that can be integrated with the deep learning approach is Problem-Based Learning (PBL). This integrated pedagogical model holds the potential to catalyze students' curiosity and creativity in chemistry, thereby enhancing both their critical and scientific thinking capacities. Consequently, this study examines the effectiveness of PBL integrated with deep learning in enhancing students' critical thinking skills and scientific frameworks in chemistry education. Utilizing a PRISMA-guided systematic literature review, this study analyzes various research articles and empirical studies published over the last five years. The reviewed articles were obtained from databases such as Google Scholar and Scopus. Inclusion criteria included the application of PBL, deep learning, or a combination of both in chemistry. The findings reveal that the integration of Problem-Based Learning with deep learning significantly enhances students' critical and scientific thinking capacities. Students are encouraged to build understanding through active inquiry, group discussions, and in-depth reflection. Furthermore, this deep learning approach fosters meaningful and sustainable learning experiences while enhancing student motivation and engagement in chemistry education, aligning with the principles of the Emancipated Curriculum.

**Keywords:** critical thinking skills; deep learning approach; emancipated curriculum; Problem-Based Learning.

## INTRODUCTION

The study by Muliana et al. (2024) stated that to prepare students to face the 21st-century global challenge, they need skills that include critical thinking, collaboration, communication and creativity. In Indonesia, the government address this requirement through a curriculum change policy in 2022,

introducing the Emancipated Curriculum (*Kurikulum Merdeka*) as an alternative option to the Kurikulum 2013. This is explained by Minarti et al. (2024) which stated that the aim of the Emancipated Curriculum is to provide a more flexible learning approach, focusing on core materials, utilizing digital technology, and giving teachers the freedom to use learning material that are suitable to the



characteristics and needs of students while still maintaining the values of Pancasila as the main foundation of education in Indonesia. Pujiningtyas et al. (2023) explained that to improve character education, the Minister of Education and Culture (*Mendikbud*) Nadiem Anwar Makarim has made the Pancasila Student Profile as one of the Vision and Mission of the Ministry of Education and Culture as stated in *Permendikbud* Number 22 of 2020 concerning the Strategic Plan of the Ministry of Education and Culture for 2020-2024. One dimension of the Pancasila Student Profile is critical thinking. By thinking critically, students can search, analyze and evaluate information, draw conclusions based on facts, and then make decisions (Hariyani, 2024). To support these policies and curricula, appropriate learning methods are needed that support the Pancasila Student Profile. In this case, Problem-Based Learning (PBL) has emerged as one method recognized for increasing student engagement and helping them develop skills relevant to the 21st century. PBL, with its student-centered learning approach and based on real-world problem solving, is considered capable of providing a more meaningful and contextual learning experience (Muliana et al., 2024).

The PBL method emphasizes the use of real problems or situations as a starting point for learning, where students are faced with complex challenges or questions that require problem solving and critical thinking (Minarti, et al., 2023). The main characteristics of PBL include: (1) a problem-based learning approach, where problems serve as a catalyst for learning; (2) collaborative learning, where students work in groups to achieve common goals; (3) integration of knowledge from various disciplines,

which allows students to develop a holistic and in-depth understanding (Muliana et al., 2024). From these characteristics, the steps taken in PBL are a) Formulating problems, the steps for students to determine the problems to be solved; b) Analyzing problems, the steps for students to review problems critically from various perspectives; c) Formulating hypotheses, the steps for students to formulate various possible solutions according to their knowledge; d) Collecting data, the steps for students to find and describe the information needed to solve problems; e) Hypothesis testing, which is the step where students draw or formulate conclusions based on the acceptance and rejection of the proposed hypothesis; f) Formulating problem-solving recommendations, which is the step where students describe recommendations that can be implemented based on the formulation of the results of hypothesis testing and the formulation of conclusions (Hariyani, 2023). In its application in Indonesia, PBL is still not considered effective due to various obstacles in its implementation, especially the difficulties faced by teachers due to limited time, resources, and inadequate training. Improvements were made by the Minister of Primary and Secondary Education (*Mendikdasmen*) Abdul Mu'ti by initiating a deep learning approach to the PBL method.

Deep learning is an approach aimed at enhancing students' capacity in the learning process. This approach is designed to make the learning experience more meaningful and enjoyable. This approach has three main elements: Mindful Learning, which emphasizes full awareness in learning; Meaningful Learning, which ensures deep and relevant understanding; and Joyful Learning, which creates a fun and

motivating learning environment for students. This approach focuses not only on conceptual mastery of the material but also emphasizes in-depth understanding and critical thinking skills. By implementing deep learning, it is hoped that education in Indonesia will produce graduates who are better prepared to face global challenges and possess the social competencies for innovative and creative thinking (Komariyah, 2025). In Indonesia, the implementation of the deep learning model aligns with the principles of the Emancipated Curriculum which prioritizes freedom of learning and emphasizes project-based learning. The deep learning approach, which emphasizes meaningful and mindful learning experiences, is highly relevant for application in the Indonesian educational context (Suwandi et al., 2024).

The deep learning approach in the PBL method is expected to reduce the difficulties encountered when implementing PBL alone and further encourage students' critical thinking skills. Accordingly, this research was conducted by reviewing the literature that presents the deep learning approach in the Problem-Based Learning method, particularly its application in the Indonesian education system, to assess its effectiveness in improving students' critical thinking skills.

## METHOD

This systematic literature review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. As explained by Page et al. (2021), the PRISMA framework provides clarity and precision in reporting the processes and outcomes of

literature reviews. Consequently, this approach was selected to guarantee high transparency, accountability, and replicability in study selection and data synthesis. Specifically, it maps the integration of Problem-Based Learning (PBL/PjBL), deep learning strategies, and high school students' critical thinking skills in chemistry education within the implementation framework of Indonesia's Emancipated Curriculum.

The inclusion criteria for this systematic literature review were structured as follows:

**Publication Year:** Articles must be published within the last five years (2022–2026) to ensure data currency and alignment with the evolving dynamics of the Emancipated Curriculum.

**Journal Reputation:** Studies must be indexed in the Scopus database and ranked within top-tier quartiles (Q1 or Q2) to guarantee methodological rigor and robust theoretical contributions.

**Thematic Focus:** Research must investigate innovative problem- or project-based learning models (PBL/PjBL), deep learning orientations or High-Order Thinking Skills (HOTS), and the development of critical thinking skills, situated within the context of the Emancipated Curriculum or comparable chemistry/science education transformations.

**Document Type:** Only peer-reviewed, original empirical research articles presenting valid primary or secondary data were considered.

Conversely, the exclusion criteria comprised: (1) studies published outside the 2022–2026 timeframe; (2) conference proceedings, book chapters, theses, dissertations, and secondary review papers; (3) journal articles indexed in Scopus Q3 or Q4, or unindexed entirely; and (4) papers lacking a distinct focus on

chemistry/science pedagogical variables, critical thinking, or the Emancipated Curriculum.

Literature search and acquisition utilized the Watase UAKE application, a specialized literature retrieval tool integrated with the Scopus API alongside Publish or Perish connected to Google Scholar. This setup ensured that the search queries harvested reliable and high-authority academic sources satisfying the inclusion criteria. This screening process initially yielded 25 highly relevant articles as the initial baseline for topical analysis. The entire process is mapped out in Figure 1.

The systematic search using specific keyword strings, including: "Problem Based Learning in High School Chemistry The systematic search using specific keyword strings, including: "Problem Based Learning in High School Chemistry Subject," "Deep learning in chemistry high school," "Critical thinking in chemistry high school," "Chemistry Emancipated Curriculum," and "Chemistry learning for High School in Indonesia." This execution yielded a total of 799 articles, comprising 345 records from Scopus and 454 from Google Scholar.

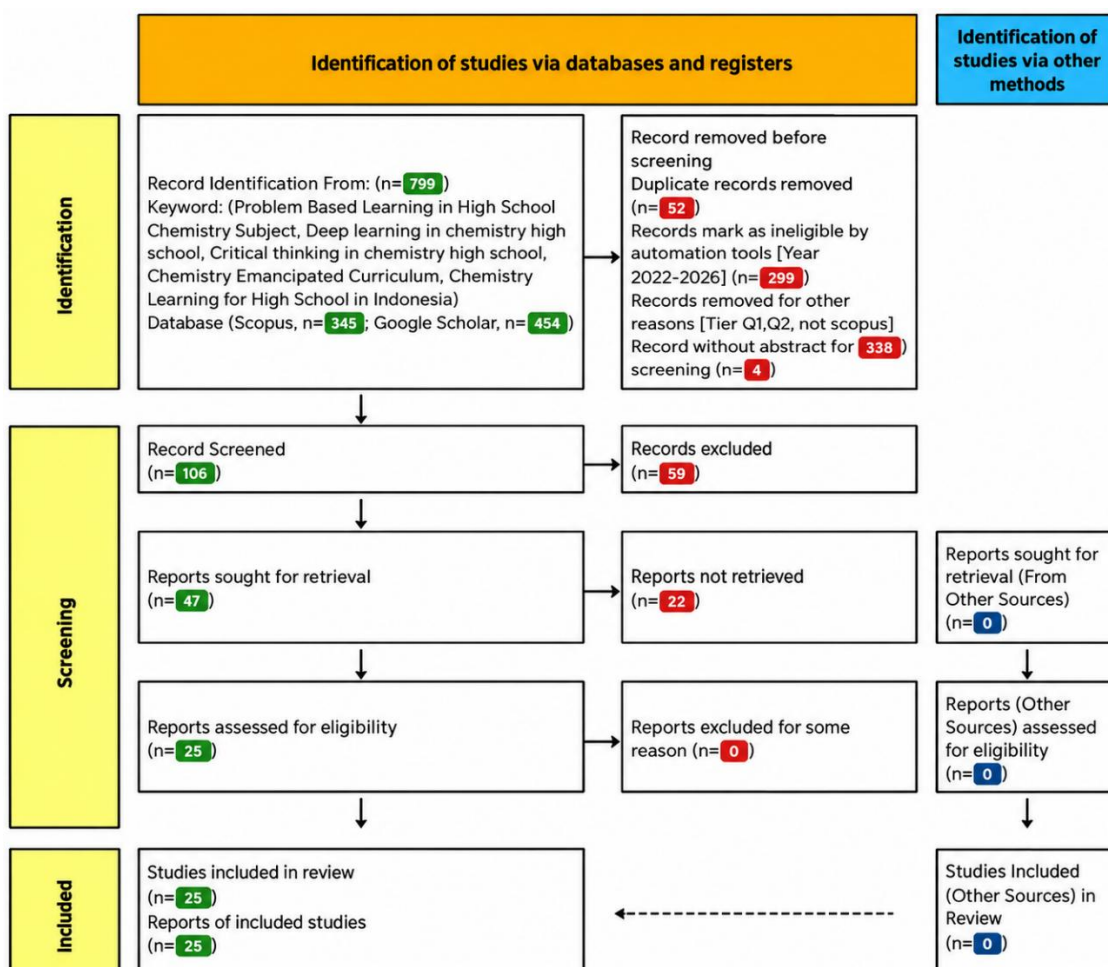


Figure 1. PRISMA 2020 flow diagram (generated via Watase Uake Tools, adapted from the PRISMA 2020 statement).

During the initial identification stage, 351 articles were automatically removed due to duplication or falling outside the specified publication years. Furthermore, 338 articles were excluded for being unindexed or falling into Scopus Q3/Q4 quartiles, and 4 articles were omitted due to the absence of an abstract for screening. This left 106 articles for title and abstract screening, from which 59 irrelevant studies were discarded. Of the remaining 47 full-text articles sought for retrieval and eligibility review, only 25 articles were successfully accessed and moved to the quality appraisal phase.

Data from these 25 eligible articles were structurally extracted using a digital coding sheet. The extracted data components included: (a) article identity (Author, Year of Publication, Journal Name); (b) Scopus indexing and quartile rank; (c) research design and methodology; (d) pedagogical interventions (PBL, PjBL, STEM, ARGBL, or E-Modules); (e) effect sizes or impact measures on critical thinking skills/HOTS; and (f) relevance to the Emancipated Curriculum implementation or learning sustainability. Each study passing the selection underwent a

methodological quality assessment using the Mixed Methods Appraisal Tool (MMAT) to ensure robust internal validity across quantitative, qualitative, and mixed-methods designs. The appraisal specifically evaluated the precision of measurement instruments, the clarity of experimental or descriptive setups, and data analysis transparency. Following this final selection appraisal, 5 articles were excluded for scoring below the 80% quality threshold, resulting in a final synthesis sample of 20 highly qualified articles.

The analytical framework relied on thematic synthesis combined with comparative descriptive analysis. Findings were categorized based on shared theoretical constructs (e.g., the influence of interactive e-modules or Augmented Reality on critical thinking dispositions) and their subsequent impact on teacher and student readiness within the Emancipated Curriculum scheme. This synthesis was mapped chronologically and logically to construct a holistic conceptualization regarding the future trajectory of chemistry education in Indonesia.

Table 1. Matrix of Characteristics of the Selected Articles included in the Review

| No | Author<br>(Year) | Article Title                                                                                                                                                       | Journal<br>(Index)                                                                      | Research Design<br>and<br>Methodology                                                                                         |
|----|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| 1. | Abbood<br>(2023) | A Training Program According to Interactive Teaching Strategies and Its Impact on Achievement and Creative Problem Solving for Fourth-Grade Preparatory Students in | iJET:<br>International<br>Journal of<br>Emerging<br>Technologies<br>in Learning<br>(Q2) | Experimental<br>pretest-posttest<br>control group design<br>evaluating 59 fourth-<br>grade preparatory<br>chemistry students. |

| No        | Author (Year)           | Article Title                                                                                                                                   | Journal (Index)                                         | Research Design and Methodology                                                                                          |
|-----------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Chemistry |                         |                                                                                                                                                 |                                                         |                                                                                                                          |
| 2.        | Ananda et al. (2023)    | Critical Thinking Skills of Chemistry Students by Integrating Design Thinking with STEAM-PjBL                                                   | JOTSE: Journal of Technology and Science Education (Q2) | Qualitative case study analysing 41 tenth-grade chemistry students utilizing collabo-rative online platform.             |
| 3.        | Creswell et al. (2024)  | Implementing an Interactive Online Platform in a Large Undergraduate General Chemistry Course and Its Impact on Student Learning and Perception | Chemistry Education Research and Practice (Q1)          | Longitudinal quantitative evaluation tracking coursework and post-survey metrics across large general chemistry cohorts. |
| 4.        | Fitriyana et al. (2024) | The Importance of Integrated STEM Learning in Chemistry Lesson: Perspectives from High School and Vocational School Chemistry Teachers          | JOTSE: Journal of Technology and Science Education (Q2) | Explorative survey design mapping a sample of 82 high school and 49 vocational school chemistry teachers.                |
| 5.        | Hao et al. (2024)       | Empirical Research on AI Technology-Supported Precision Teaching in High School Science Subjects                                                | Applied Science (Q1)                                    | Quantitative/empirical study evaluating teaching burdens and student Learning diagnostics.                               |
| 6.        | Irwanto et al. (2026)   | The Effect of Augmented Reality Game-Based Learning on Students' Critical Thinking Disposition and Academic Achievement                         | JOTSE: Journal of Technology and Science Education (Q2) | Quasi-experimental pretest-posttest control group design with 72 tenth-grade chemistry students in Jakarta.              |

| No  | Author (Year)                 | Article Title                                                                                                                                        | Journal (Index)                                                        | Research Design and Methodology                                                                     |
|-----|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 7.  | Jammeh et al. (2023)          | The Interactive Classroom: Integration of SMART Notebook software in Chemistry Education                                                             | EURASIA: Journal of Mathematics, Science and Technology Education (Q2) | Quantitative study analysing post-survey data and student academic performance statistics.          |
| 8.  | Lathwesen & Eilks (2024)      | Can You Make It Back to Earth? A Digital Educational Escape Room for Secondary Chemistry Education to Explore Selected Principles of Green Chemistry | Journal of Chemical Education (Q1)                                     | Mixed-methods evaluative case study mapping the response of 91 secondary school chemistry students. |
| 9.  | Lopez-Fernandez et al. (2022) | How Can Socio-scientific Issues Help Develop Critical Thinking in Chemistry Education? A Reflection on the Problem of Plastics                       | Journal of Chemical Education (Q1)                                     | Mixed-methods evaluation featuring classroom interventions with secondary students.                 |
| 10. | Mahunyag et al. (2024)        | ELQUAN: A Game-Based Learning Tool to Master Electron Configuration and Quantum Numbers                                                              | Journal of Chemical Education (Q1)                                     | Quantitative quasi-experimental research utilizing paired t-test metrics.                           |
| 11. | Neffat & Bonomi (2024)        | Exploring Density in a New Way: A Problem-Solving Activity with Increasing Complexity, Based on Length Measurements                                  | Journal of Chemical Education (Q1)                                     | Qualitative descriptive case study monitoring student laboratory trajectories.                      |
| 12. | Purwanto et al. (2022)        | Socio-Critical and Problem-Oriented Approach in                                                                                                      | JOTSE: Journal of                                                      | Qualitative framework with comprehensive                                                            |

| No  | Author<br>(Year)           | Article Title                                                                                                                                                                     | Journal<br>(Index)                                           | Research Design<br>and<br>Methodology                                                                                              |
|-----|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
|     |                            | Environmental<br>Issues for Students'<br>Critical Thinking<br>Development in<br>Chemistry<br>Learning                                                                             | Technolo<br>gy and<br>Science<br>Educatio<br>n (Q2)          | data collection<br>(interviews,<br>observations,<br>reflective<br>journals).                                                       |
| 13. | Rahmawati<br>et al. (2023) | Chemistry Learning<br>Through Culturally<br>Responsive<br>Transformative<br>Teaching (CRTT):<br>Educating Indonesian<br>High School<br>Students for<br>Cultural<br>Sustainability | Sustainability<br>(Q1)                                       | Qualitative<br>transformative<br>research using a<br>mini-ethnographic<br>case study with<br>high school<br>chemistry<br>students. |
| 14. | Rahmawati<br>et al. (2022) | Students'<br>Engagement in<br>Education as<br>Sustainability:<br>Implementing an<br>Ethical Dilemma-<br>STEAM Teaching<br>Model in<br>Chemistry Learning                          | Sustainability<br>(Q1)                                       | Qualitative<br>transformative<br>research tracking<br>holistic<br>educational<br>engagements.                                      |
| 15. | Tang & Putra<br>(2025)     | Generative AI as a<br>Dialogic Partner:<br>Enhancing Multiple<br>Perspectives,<br>Reasoning, and<br>Argumentation in<br>Science Education<br>with Customized<br>Chatbots          | Journal of<br>Science<br>Education and<br>Technology<br>(Q1) | Qualitative and<br>quantitative case<br>study utilizing<br>human-AI chatlog<br>text analyses.                                      |
| 16. | Winaryati et<br>al. (2025) | Developing 21st<br>Century Skills<br>Through STEM-<br>Based<br>Lesson Study and<br>Project-Based<br>Approaches in<br>Chemistry Learning                                           | Educational<br>Process<br>International<br>Journal (Q1)      | Action research<br>incorporated with<br>lesson study<br>frameworks.                                                                |
| 17. | Wiratma &                  | Ethnochemistry                                                                                                                                                                    | JPPII:                                                       | Quantitative                                                                                                                       |

| No  | Author<br>(Year)            | Article Title                                                                                                                                                                      | Journal<br>(Index)                                     | Research Design<br>and<br>Methodology                                                                                                      |
|-----|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
|     | Yuliamiastuti<br>(2023)     | Potential of Vines<br>Contained in Lontar<br>Usada Taru Pramana<br>on Students'<br>Scientific<br>Explanation Skills<br>Through Task-Based<br>Learning                              | Jurnal<br>Pendidika<br>n IPA<br>Indonesia<br>(Q2)      | methodology<br>using a One-<br>Group pretest-<br>post test<br>replication design<br>with 234 high<br>school and<br>vocational<br>students. |
| 18. | Yakob et al.<br>(2023)      | The Feasibility<br>of Authentic<br>Assessment<br>Instrument<br>Through Virtual<br>Laboratory<br>Learning and Its<br>Effect on Increasing<br>Students'<br>Scientific<br>Performance | Journal of<br>Baltic<br>Science<br>Education<br>(Q2)   | Quasi-<br>experimental<br>design involving<br>secondary high<br>school chemistry<br>students.                                              |
| 19. | Yerimadesi<br>et al. (2026) | The Influence of<br>Gender and Problem-<br>Based Learning<br>Model on<br>Students'<br>Numerical<br>Literacy in<br>Chemistry                                                        | JPII: Jurnal<br>Pendidikan<br>IPA<br>Indonesia<br>(Q2) | Quantitative<br>quasi-<br>experimental<br>approach<br>employing a non-<br>equivalent control<br>group.                                     |
| 20. | Zamjani et<br>al. (2026)    | The (Un)willingness<br>to Learn: Teachers'<br>Responses to Recent<br>Curriculum Reform<br>in Rural Indonesia                                                                       | Asia<br>Pacific<br>Journal of<br>Education<br>(Q1)     | Qualitative<br>case study<br>exploring<br>teacher<br>adaption<br>behaviors<br>and<br>professional<br>learning.                             |

## RESULT AND DISCUSSION

In general, the selected articles included in the review were published between 2022 and 2026 reflecting high data novelty in tracking the dynamics of development in modern chemistry education research. Furthermore, these sources provide primary data and are published in Scopus Q1 and Q2 indexed journals, ensuring the accuracy of the study findings. To align with the study topic, all articles were reviewed from three distinct perspectives.

**Pedagogical interventions.** Deep learning integration into Problem-Based Learning (PBL) must be accompanied by the readiness of both teachers and students. Teachers are trained to shift from conventional methods to more interactive and student-centred approaches, as demonstrated by Abbood (2023). This aligns with research by Zamjani et al. (2026) which evaluates teachers' pedagogical readiness in implementing PBL integrated with deep learning within the Emancipated Curriculum (*Kurikulum Merdeka*), especially in remote areas. To optimize the implementation of integrated learning methods within the Emancipated Curriculum, both educators and students must actively engage in learning process. A practical application of deep learning is demonstrated through the STEM (Science, Technology, Engineering, Mathematics) model, which can be expanded into the STEAM model by integrating an Arts component. This interdisciplinary method examines a problem through multiple scientific perspectives. While Rahmawati et al. (2022) and Fitriyana et al. (2024) investigated the general application of this method, Ananda et al. (2023)

prioritized Design Thinking as one of the STEM/STEAM-based learning approaches. Given the critical role of teacher readiness highlighted earlier, Winaryati et al. (2025) examined the impact of STEM integration on both teacher professional development and student achievement. Contextual understanding is fundamental to deep learning in providing meaningful educational experiences. To foster this, the problems investigated are drawn from real-world situations. Neffat & Bonomi (2024) implemented this contextual approach within concrete laboratory activities, whereas real-world applications manifested as socio-cultural issues intertwined with local wisdom. Such real-world problems are evident across various studies. Lopez-Fernandez et al. (2022) utilized a socio-scientific approach to address plastic pollution, while Purwanto et al. (2022) focused on contemporary Indonesian environmental issues through a socio-critical lens. Meanwhile, Rahmawati et al. (2023) employed the Culturally Responsive Transformative Teaching (CRTT) model to integrate chemistry learning with the cultural backgrounds and local wisdom of Indonesian high school students, thereby supporting cultural sustainability. This approach aligns with the study of Wiratma & Yuliamiastuti (2023), who explored the potential of traditional Balinese healing practices from ethnochemical perspective. Modern technological support is inseparable from the implementation of this deep learning. Lathwesen & Eilks (2024), Mahunyang et al. (2024), and Irwanto et al. (2026) investigated game-based learning, while digital media applications were diversified across digital platforms (Cresswell et al., 2024), smart notebooks (Jammeh et al., 2023),

and virtual laboratories (Yakob et al., 2023). This technological ecosystem is further enhanced by AI-driven learning activities, as examined by Hao et al. (2024) and Tang & Putra (2025). Finally, the influence of gender on the overall PBL process was highlighted by Yerimadesi et al. (2026).

Impact on critical thinking skills. Overall, the reviewed literature indicates that Problem-Based Learning integrated with deep learning positively impacts students' critical thinking sub-skills that encompass problem-solving, analytical thinking, independent learning, scientific reasoning, multi-perspective evaluation, and the application of numerical literacy. This positive trajectory is clearly demonstrated by elevated student academic achievement (Irwanto et al., 2026). Specifically, Purwanto et al. (2022) and Ananda et al. (2023) noted that the methodology prompts students to frame complex problems and generate solutions, which serves as a catalyst for cognitive development. From an instructional standpoint, Zamjani et al. (2026) emphasized that cultivating critically reflective thinking among educators is equally vital to ensure this pedagogical transformation is comprehensively implemented.

Correlation to the implementation of the Emancipated Curriculum. Generally, the reviewed articles demonstrated a strong congruence with the Indonesian Emancipated Curriculum through the adoption of contextual and student-centred pedagogies. These studies align closely with the curriculum's core pillars, namely differentiated learning, interdisciplinary students' projects, and the establishment of teacher learning communities. Furthermore, this approach fosters the Profil Pelajar Pancasila (Pancasila

Students Profile) dimensions including critical reasoning, creativity, global diversity, collaboration, independence, and environmental awareness. For instance, Wiratma & Yuliamastuti (2023) embedded local wisdom into contextual learning, a core of this curriculum while Rahmawati et al. (2023) proved that such integration in chemistry education supports cultural sustainability. Additionally, as Neffat & Bonomi (2024) proposed, the curriculum principles intersect with digital transformation and social justice, culminating in three ultimate goals: Mindful, Meaningful, and Joyful Learning. Meanwhile, Zamjani et al. (2026) highlighted the challenges in implementing this curriculum, emphasizing the need for curriculum flexibility, continuous training, and localized adaptation, particularly in the frontier, outermost, and disadvantaged areas (3T regions).

## CONCLUSION

This systematic literature review confirms that integrating deep learning frameworks into Problem-Based Learning (PBL) effectively enhances critical and scientific thinking skills in chemistry education. This integrated learning method drives a shift from conventional, theoretical, teacher-centred method to active, student-centred learning.

Although this study was conducted systematically and objectively, several limitations must be acknowledged: (1) The inclusion criteria, which limited the scope to Scopus Q1 and Q2 indices, potentially eliminated accredited national journals (such as SINTA) or Q3 and Q4 indexed international journals

that extensively examine the practical, massive applications of the Emancipated Curriculum; (2) The entire PRISMA and MMAT processes were conducted by a single reviewer. While subjectivity bias was minimized, the involvement of an additional independent reviewer remains ideal to enhance the validity of the study; (3) The sample size of 20 articles requires caution when generalizing the findings across all sub-topics in chemistry learning

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