PAEDAGOGIA
Jurnal Penelitian Pendidikan
http://jurnal.uns.ac.id/paedagogia

DOI : 10.20961/Paedagogia.v28i2.102722
Vol. 28, No. 2, 2025, pp. 347-354
p-ISSN 0126-4109
e-ISSN 2549-6670

# The Effect of Problem-Based Learning on Scientific Argumentation Skills in the Merdeka Belajar Curriculum

Wiwik Kartika Sari*, Nidaul Hasanah, Ella Izzatin Nada
Chemistry Education Department, Faculty of Science and Technology, UIN Walisongo Semarang, Semarang, Indonesia

**Keywords:** *PBL, HOTS, scientific argumentation*

**Article history**
Received: 22 May 2025
Revised: 18 June 2025
Accepted: 18 June 2025
Published: 21 June 2025

*Corresponding Author Email:
wiwik.kartika@walisongo.ac.id

Doi: 10.20961/paedagogia.v28i2.102722



**Abstract:** PBL encourages students to think openly, actively, and reflectively. Scientific argumentation is a core competency emphasized in the Merdeka Belajar curriculum to foster critical thinking, problem-solving, and scientific literacy. This study investigates the effect of the Problem-Based Learning (PBL) model on students' scientific argumentation skills in high school chemistry learning. Using a quasi-experimental non-equivalent pretest-posttest control group design, two classes were selected through cluster random sampling (n = 32 for each). The experimental class was taught using the PBL model, while the control class used conventional teacher-centered instruction focused on concept explanation and textbook exercises. Scientific argumentation skills were measured using a set of open-ended questions based on Toulmin's Argumentation Pattern (TAP) and scored using an expert-validated rubric assessing claim, data, warrant, and rebuttal. The results showed a significant improvement in the experimental class (pre-test mean = 38.21; post-test mean = 78.65) compared to the control class (pre-test mean = 37.92; post-test mean = 60.73), with a significance level of $p < 0.05$. This indicates that the PBL model enhances students' ability to construct, justify, and evaluate scientific arguments more effectively than traditional instruction. These findings suggest that integrating PBL into science teaching can support the development of argumentation skills that are aligned with the goals of the Merdeka Belajar curriculum. It highlights the importance of shifting classroom practices toward student-centered learning models that promote reasoning and discourse.

**How to cite:** Sari, W. K., Hasanah, N. & Nada, E. I. (2025). The Effect of Problem-Based Learning on Scientific Argumentation Skills in the Merdeka Belajar Curriculum. *PAEDAGOGIA*, *28*(2), 347-354. doi: 10.20961/paedagogia.v28i2.102722

## INTRODUCTION

In the 21st-century learning environment, scientific argumentation is considered a critical skill in science education. It enables students to comprehend scientific concepts and construct claims supported by valid evidence and logical reasoning. As a subset of higher-order thinking skills (HOTS), scientific argumentation promotes critical thinking, problem-solving, and effective communication, which are essential for scientific literacy and meaningful learning (Hosbein et al., 2021; Songsil et al., 2019). The ability to argue in a structured, reflective, and well-formed manner is a subset of higher-order thinking skills. This skill is significant for communication, collaboration, and problem-solving, all of which are integral to scientific argumentation (Akçay, 2009; Tama et al., 2020). The ability to engage in structured and reflective argumentation is crucial in chemistry, where students must navigate complex, abstract concepts and make sense of empirical evidence.

Despite its importance, scientific argumentation remains underdeveloped in many Indonesian classrooms. Preliminary observations and interviews with chemistry teachers indicated that students often struggle to articulate arguments beyond the claim level, lacking reasoning and evidence to support their ideas. Teachers tend to rely on conventional instructional methods and assessments that emphasize lower-order cognitive skills (C1–C3), such as memorization and simple recall. These approaches fail to stimulate students' analytical thinking or foster their capacity to argue scientifically. Based on the interview results and documentation studies, it is known that in the learning process, teachers have not implemented a model that stimulates students' scientific argumentation skills. Some teachers do not even understand the indicators of students' scientific argumentation skills. The learning process carried out by teachers still focuses on the cognitive aspects of understanding concepts. Moreover, many teachers are not familiar with the indicators of scientific argumentation and experience difficulties in selecting learning models that can support students in developing these skills.

In line with Indonesia's national education reform, the Merdeka Belajar curriculum emphasizes student-centered learning, inquiry, and the development of critical and reflective thinking. However, there is a clear gap between curriculum expectations and classroom implementation. Most learning practices still emphasize cognitive understanding without integrating reasoning and discourse. Documentation studies further revealed that teachers face challenges not only in applying relevant models but also in designing assessments that go beyond factual recall. These issues signal the need for innovative and practical pedagogical approaches to promote higher-order thinking skills, especially argumentation skills, by the Merdeka Belajar vision.

Despite widespread international recognition of Problem-Based Learning (PBL) as an effective method to foster higher-order thinking and scientific reasoning, few studies have examined its role in promoting scientific argumentation in Indonesian classrooms. Most local research on PBL has focused on general learning outcomes such as academic performance or problem-solving ability, with limited exploration into how PBL supports structured scientific argumentation. There is also a lack of studies that contextualize the application of PBL within the framework of Merdeka Belajar, particularly in chemistry education, where students must integrate abstract knowledge with evidence-based reasoning.

PBL encourages students to think openly, actively, and reflectively, which are essential components of critical thinking (Astuti et al., 2018; Hsiao et al., 2022). This active engagement helps students to analyze and evaluate information critically. PBL has been shown to significantly enhance students' higher-order thinking skills by engaging them in complex problem-solving tasks. Therefore, PBL requires students to apply various concepts, principles, and skills they have learned to solve real-world problems. This process inherently develops their ability to think logically and make informed decisions (Kousloglou et al., 2023; Lu et al., 2021). For instance, studies have demonstrated that PBL outperforms traditional lecture-based methods in improving self-regulated learning and HOTS (Sugeng & Suryani, 2019; Tâm, 2021; Yulianti et al., 2020). PBL encourages students to work cooperatively in groups, fostering skills such as collaboration and communication, which are essential for HOTS. PBL is particularly effective in contexts where students need to apply theoretical knowledge to practical scenarios, thereby enhancing their analytical and problem-solving abilities (Akçay, 2009; Tama et al., 2020)

This study addresses these gaps by investigating the effect of Problem-Based Learning on students' scientific argumentation skills within the implementation of the Merdeka Belajar curriculum. The novelty of this study lies in its integration of PBL with scientific argumentation in an authentic Indonesian high school chemistry context, offering empirical insights into effective classroom practices aligned with national educational reforms. The findings are expected to inform both pedagogical theory and classroom practice, providing a foundation for improving argumentation-based learning strategies in science education.

## METHOD

This research is a quantitative study with a quasi-experimental design. This study used a non-equivalent pretest-posttest control group design. The control and experiment classes were given the same treatment; the experiment class used a problem-based learning model while the control class used conventional teacher-centered instruction. The population in this study was grade XI students in one of the public schools in Kudus. The sample was determined through cluster random sampling, and 2 classes were selected as control and experiment classes, with 32 students each.

Data collection was carried out using scientific argumentation questions that had been declared valid by experts according to the results in Table 1. The questions were in the form of essays with 8 questions. The data were then analyzed to determine students' scientific argumentation skills in chemistry learning in the era of the Merdeka Belajar curriculum.

## RESULT AND DISCUSSION

**Table 1.** Aiken's Index of Indicator Suitability

| Number | Rateurs | | | Aiken's Index |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| 1 | 5 | 5 | 5 | 0,95 |
| 2 | 5 | 5 | 5 | 0,95 |
| 3 | 4 | 5 | 5 | 0,85 |
| 4 | 5 | 5 | 5 | 1 |
| 5 | 4 | 5 | 5 | 0,95 |
| 6 | 5 | 5 | 5 | 1 |
| 7 | 5 | 4 | 5 | 0,95 |
| 8 | 5 | 5 | 5 | 1 |

Table 1 shows the results of expert agreement on the suitability of indicators expressed in the index. The resulting Aiken's index obtained an average of 0.97, with the smallest index of 0.85 and the largest index of 1. The index obtained is greater than 0.8, with a high category. Based on the results of the analysis, it can be concluded that the expert agreed that the indicators of the questions developed in the test instrument were appropriate.

**Table 2.** Aiken Index of Concept Correctness

| Number | Rateurs | | | Aiken's Index |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| 1 | 5 | 5 | 5 | 0,95 |
| 2 | 4 | 5 | 5 | 0,85 |
| 3 | 5 | 5 | 5 | 1 |
| 4 | 5 | 5 | 5 | 1 |
| 5 | 5 | 5 | 5 | 1 |
| 6 | 5 | 4 | 5 | 0,95 |
| 7 | 5 | 5 | 5 | 1 |
| 8 | 5 | 5 | 5 | 1 |

Table 2 shows the results of expert agreement on the correctness of the reaction rate concept developed in the test instrument. Expert agreement is summarised in Aiken's index. The index results obtained an average index of 0.97, with the smallest index of 0.85 and the largest index of 1. The index obtained is greater than 0.8 with a high category. The analysis results showed that the experts agreed that concepts developed in the test instrument were correct or appropriate.

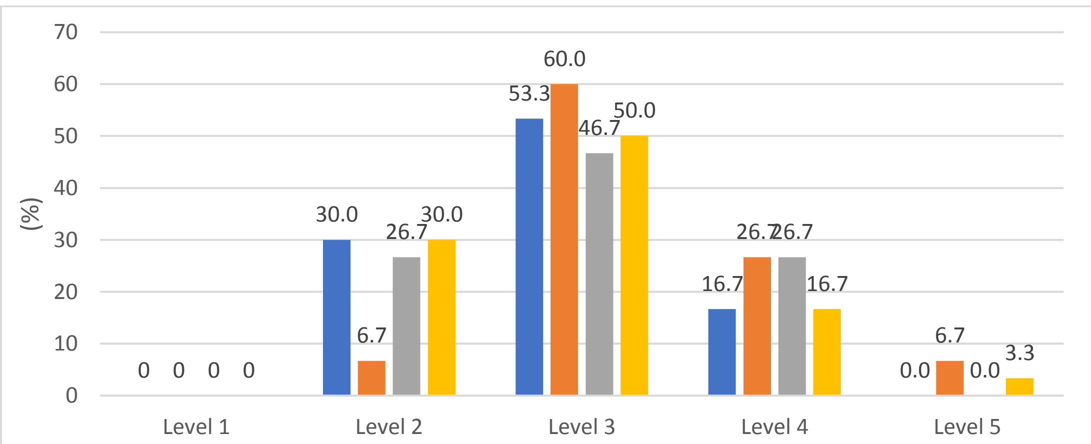


**Figure 1.** Claim aspect

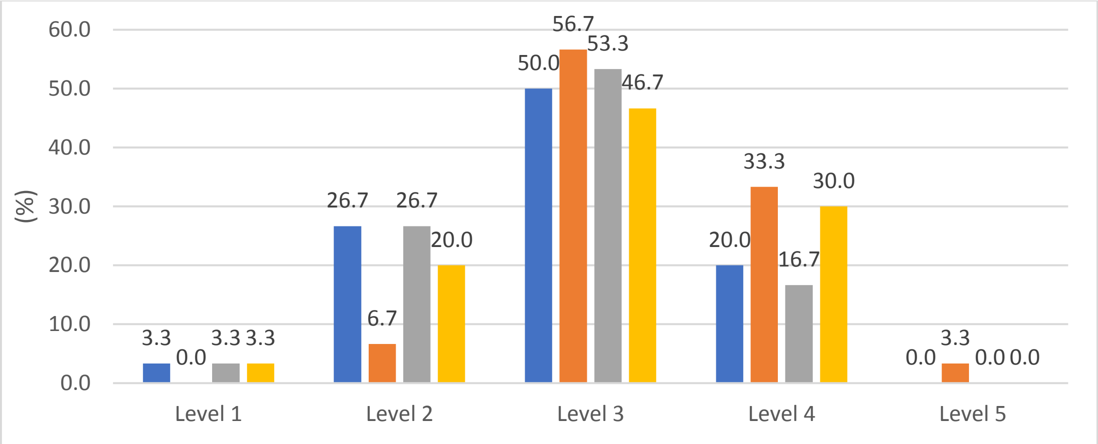


**Figure 2.** Evidence aspect

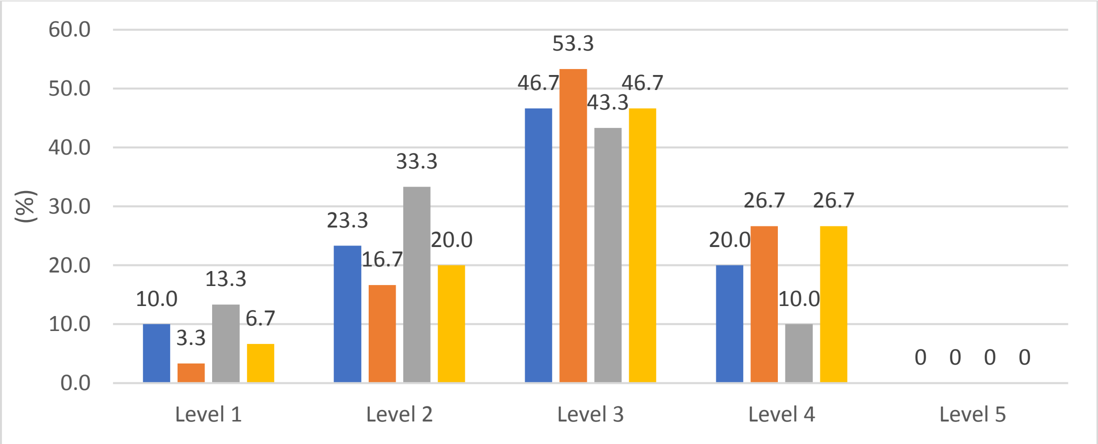


**Figure 3.** Reasoning aspect

This study examined the effectiveness of the Problem-Based Learning (PBL) model in enhancing students' scientific argumentation skills within Indonesia's Merdeka Belajar curriculum. The results provide compelling evidence that PBL leads to a statistically significant improvement in students' abilities to construct, support, and critique scientific arguments, as demonstrated by the experimental group's performance. Quantitative findings show that students in the PBL-based experimental class improved their mean scores from 38.21 in the pre-test to 78.65 in the post-test. In comparison, the control group, which received conventional instruction focusing on textbook-based explanation and teacher-led questioning, showed a more modest improvement; from 37.92 to 60.73. This differential gain indicates that while both teaching strategies yielded learning progress, the extent of improvement in the experimental group was notably greater ($p < 0.05$). The nature of PBL, which emphasizes open-ended problems and student-led inquiry, likely provided more frequent and varied opportunities for students to construct, present, and defend scientific arguments (Aguiar et al., 2021; Birgili, 2015; Pratiwi et al., 2019).

This outcome suggests that PBL provides a learning environment more conducive to developing scientific argumentation skills. In contrast to conventional approaches that prioritize content transmission and factual recall, PBL encourages active exploration, collaborative problem-solving, and the articulation of reasoning. Students are placed in situations where they must not only arrive at a solution but also justify their thinking using evidence and logic. These results are consistent with previous research. Brown et al. (2016) reported that middle school students who participated in a PBL program called GlobalEd 2 demonstrated significant gains in written scientific argumentation, with an effect size of 0.257 ($p < 0.001$). Jumadi et al. (2021) found that students engaged in a PBL approach supported by argument mapping and online laboratories achieved a mean gain score of 0.43 in scientific argumentation skills. These findings reinforce that PBL structures foster higher-order thinking through real-world problem contexts and reflective discourse.

To better understand the nature of the observed improvement, it is important to consider the specific components of scientific argumentation. Drawing on Toulmin's Argument Pattern (TAP), effective scientific arguments consist of several core elements: claims, data (evidence), warrants (justifications), and optionally, rebuttals. Students in the experimental group showed clear gains across all these dimensions, as observed in their post-test responses. In the pre-test, most students in both groups could only produce partial arguments, often limited to a simple claim without adequate evidence or reasoning. After the intervention, however, students in the PBL group could construct more sophisticated responses, linking their claims with specific scientific data, providing justifications grounded in principles of chemistry, and, in some cases, anticipating counterarguments. This indicates not only an improvement in cognitive skill but also an increase in metacognitive awareness and epistemic understanding.

From a constructivist perspective, these gains can be attributed to the social and cognitive mechanisms embedded in PBL. According to Vygotsky, learning is mediated through social interaction and dialogue (Vygotsky, 1978). PBL environments naturally foster peer discussion, negotiation of meaning, and collaborative reasoning; processes essential for constructing scientific knowledge. When students work in groups to solve open-ended problems, they are not only exposed to multiple perspectives but also challenged to defend their ideas and revise their thinking in response to peer feedback. Moreover, Toulmin's model offers more than a descriptive framework, it functions as a cognitive scaffold that aligns well with the dialogic nature of PBL. By requiring students to support their claims with data and logical justifications, PBL implicitly operationalizes the TAP structure. Students learn, through iteration and reflection, how to build robust arguments, an ability that is foundational for scientific literacy and democratic citizenship alike.

Previous studies also highlight that effective science instruction should go beyond content delivery and support discourse and debate. The PBL model provides students with authentic contexts where argumentation becomes necessary, not just an academic exercise. This deeper engagement contrasts with more guided approaches like the inquiry model, which may restrict the extent to which students formulate and justify their own scientific reasoning. PBL encourages students to engage more deeply with each of these elements as they attempt to solve real-world problems collaboratively (Dewi et al., 2021; Tong et al., 2022). The structure of PBL inherently promotes critical thinking and reasoning, requiring students to defend their solutions with data and logical reasoning. A study on high school students' learning showed a high correlation (0.639) between PBL and improved argumentation skills, which in turn facilitated better understanding of scientific concepts (Pratiwi et al., 2019).

The improvement in argumentation skills through PBL can be explained through several theoretical lenses. From a constructivist perspective, PBL aligns with Vygotsky's emphasis on social interaction as a driver of cognitive development. When students engage in collaborative problem-solving, they are naturally prompted to explain, defend, and question each other's thinking core elements of scientific argumentation. Additionally, Toulmin's Argument Pattern (TAP) serves as a practical tool to analyze and scaffold students' arguments. PBL offers iterative opportunities for students to formulate claims, support them with data, provide warrants, and even address counterarguments (rebuttals), a higher-order skill often neglected in traditional instruction.

When instruction explicitly promotes argument-based reasoning, students gain a deeper understanding of scientific concepts and develop transferable critical thinking skills. Similarly, Simon et al., (2006) emphasized the role of classroom discourse in science education, noting that structured opportunities to argue are crucial for developing epistemic understanding. The findings highlight the importance of incorporating PBL as a regular feature of science classrooms, especially when cultivating students' argumentation competence. Teachers should be equipped with tools and strategies to design open-ended problems that stimulate reasoning, foster dialogue, and encourage evidence-based claims. For future research, it would be valuable to explore which types of problems are most effective in promoting argumentation and how individual differences among students interact with PBL to influence learning outcomes.

While both the experimental and control groups showed improvement in students' scientific argumentation skills, the experimental class taught using the Problem-Based Learning (PBL) model experienced significantly higher gains. In contrast, the control class, which received traditional instruction dominated by textbook explanation and teacher-led discussion, demonstrated only moderate progress. Traditional instruction in the control group emphasized content delivery, where students were expected to absorb concepts and reproduce them in assessments. This approach typically offers limited opportunities for students to engage in argument construction, evaluation of evidence, or meaningful scientific discourse. Students may memorize factual information without deeply understanding the reason behind it or applying it in new contexts.

By contrast, PBL creates an environment where students are continually challenged to construct explanations, justify their reasoning, and defend their conclusions through interaction and inquiry. Rather than being passive recipients of knowledge, students in the PBL group actively identified problems, proposed hypotheses, evaluated information, and communicated their findings. This process inherently cultivates the core elements of scientific argumentation—claim, evidence, and justification—within an authentic learning setting. The performance gap between the two groups suggests that while traditional instruction may suffice for developing lower-order thinking skills such as recall and basic comprehension, it falls short in promoting higher-order thinking processes essential for scientific reasoning. This is consistent with findings from Dewi et al., (2021), who argue that traditional models of instruction fail to promote critical reasoning unless explicitly structured to do so.

Moreover, PBL's emphasis on collaborative learning and real-world problem-solving creates natural contexts where argumentation is necessary and valued. Students are not only expected to reach conclusions but must also articulate their reasoning and respond to peer critique. These conditions are largely absent in traditional classrooms, where teacher authority often overrides dialogic engagement. Therefore, the more substantial improvement observed in the PBL group underscores the need for shifting instructional paradigms in science education—away from rigid, content-driven delivery and toward more student-centered, reasoning-rich environments that align with the goals of the Merdeka Belajar curriculum.

While the findings of this study provide strong evidence for the effectiveness of the Problem-Based Learning (PBL) model in improving students' scientific argumentation skills, several limitations must be acknowledged to ensure a balanced interpretation. First, the study was conducted in a specific context—two chemistry classes within a single school—which limits the generalizability of the findings. Although the sample size ($n = 64$) is sufficient for statistical analysis, the cultural, curricular, and teacher-related variables may differ across schools, districts, or regions in Indonesia. Future studies should consider larger and more diverse populations to validate the broader applicability of these results.

Second, while statistical significance was achieved ($p < 0.05$), this study did not calculate effect size, which would provide a clearer picture of the practical impact of PBL on learning outcomes. Including measures such as Cohen's d or partial eta squared in future research would help quantify the magnitude of learning gains and enhance the interpretive value of the results. Third, the design did not fully account for potential confounding variables, such as teacher effect or students' prior exposure to inquiry-based instruction. Although the same teacher conducted both experimental and control treatments to reduce variability, subtle differences in instructional style or engagement may have influenced student outcomes. Moreover, while the instrument used to assess argumentation was validated through Aiken's V, this validation process was described more extensively than the actual student performance. A more thorough analysis of how students performed across specific indicators (e.g., claim, evidence, reasoning, rebuttal) would provide richer insights into which aspects of argumentation were most affected by the intervention.

The study also did not explore the long-term retention of argumentation skills. While post-test results indicate improvement, it remains unclear whether these gains would persist over time without continued exposure to PBL or similar pedagogical practices. Further studies could examine the sustainability of these cognitive skills and how they transfer across disciplines. Despite these limitations, the implications of the findings are clear and meaningful, especially within the framework of Indonesia's Merdeka Belajar curriculum. This policy advocates for autonomy in learning, critical thinking, and real-world application of knowledge, all supported by the PBL model. The present study provides empirical support for integrating PBL into regular science instruction to bridge the gap between policy aspirations and classroom practice.

Synthesizing the findings of this study reveals that Problem-Based Learning (PBL) is not only a viable alternative to traditional instruction but a transformative pedagogical approach for advancing students' scientific argumentation skills. By placing students at the center of learning and engaging them in solving contextual, real-world problems, PBL encourages the construction of knowledge through reasoning, evidence evaluation, and peer discourse—all foundational to scientific literacy. These improvements are particularly relevant to the goals of the Merdeka Belajar curriculum, which emphasizes autonomy, collaboration, and critical thinking. Yet, as the current study indicates, implementing such pedagogical shifts requires more than just curriculum mandates; it demands a change in classroom culture, teacher preparation, and assessment practices. Teachers must deliver content and facilitate the construction and negotiation of ideas, creating spaces where students feel empowered to argue, challenge, and revise their thinking. The results also support broader theoretical assertions about how students learn science. Through the lens of constructivist theory, learning is most effective when it is active, social, and situated in meaningful contexts. Toulmin's Argument Pattern (TAP), in this regard, serves both as a descriptive model and a pedagogical tool, enabling students to internalize the structure of sound arguments while navigating complex scientific ideas.

## CONCLUSION

Based on the study result, it is known that the Problem-Based Learning (PBL) model significantly improves students' scientific argumentation skills compared to conventional instruction. The experimental group, which received PBL-based learning, showed a marked increase in performance, from a pre-test mean of 38.21 to a post-test mean of 78.65. In contrast, the control group improved from 37.92 to 60.73. Statistical analysis confirmed that this difference was significant ($p < 0.05$), indicating that PBL has a more substantial impact on the development of students' ability to construct, justify, and critique scientific arguments. These results confirm that PBL not only supports conceptual understanding but also fosters higher-order thinking skills and critical reasoning through structured collaborative problem-solving. In addition, PBL can be considered an effective pedagogical strategy to cultivate scientific discourse and reasoning in the classroom. Future research is encouraged to explore long-term impacts of PBL, its application across diverse student populations, and the integration of argumentation-focused scaffolding in science curricula.

## REFERENCES


Aguiar, L. L., Oliveira, H., Costella, T., Perito, P., Lorenzin, M., & Villar, R. P. (2021). Project-based learning and design thinking to develop skills and competences in high school students. *International Research Symposium on PBL*, 149–160. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85113174483&partnerID=40&md5=31be20ee6c99d0c0e7b465fa26645e1a

Akçay, B. (2009). Problem-based learning in science education. *Journal of Turkish Science Education*, *6*(1), 26–36. https://www.scopus.com/inward/record.uri?eid=2-s2.0-67650232993&partnerID=40&md5=e0d8ea1fb0a5061e3c9dc7c436818ac9

Astuti, S., Danial, M., & Anwar, M. (2018). Pengembangan LKPD Berbasis PBL (Problem Based Learning) untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik pada Materi Kesetimbangan Kimia. *Chemistry Education Review (CER)*, *1*(2), 90–114.

Birgili, B. (2015). Creative and Critical Thinking Skills in Problem-based Learning Environments. *Journal of Gifted Education and Creativity*, *2*(2), 71–80. https://doi.org/10.18200/jgedc.2015214253

Brown, S. W., Lawless, K. A., Rhoads, C., Newton, S. D., & Lynn, L. (2016). Increasing Students' Science Writing Skills Through a PBL Simulation. *13th International Conference on Cognition and Exploratory Learning in Digital Age*, 86–94.

Dewi, D. K., Ardhana, W., Chusniyah, T., & Sulianti, A. (2021). Inquiry-based learning implementation to improve critical thinking of prospective teachers. *International Journal of Information and Education Technology*, *11*(12), 638–645. https://doi.org/10.18178/IJIET.2021.11.12.1575

Hosbein, K. N., Lower, M. A., & Walker, J. P. (2021). Tracking Student Argumentation Skills across General Chemistry through Argument-Driven Inquiry Using the Assessment of Scientific Argumentation in the

Classroom Observation Protocol. *Journal of Chemical Education*, *98*(6), 1875–1887. https://doi.org/10.1021/acs.jchemed.0c01225
Hsiao, H.-S., Chen, J.-C., Chen, J.-H., Zeng, Y.-T., & Chung, G.-H. (2022). An Assessment of Junior High School Students' Knowledge, Creativity, and Hands-On Performance Using PBL via Cognitive–Affective Interaction Model to Achieve STEAM. *Sustainability*, *14*(9), 5582. https://doi.org/10.3390/su14095582
Jumadi, J., Perdana, R., Riwayani, R., & Rosana, D. (2021). The impact of problem-based learning with argument mapping and online laboratory on scientific argumentation skill. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(1), 16. https://doi.org/10.11591/ijere.v10i1.20593
Kousloglou, M., Petridou, E., Molohidis, A., & Hatzikraniotis, E. (2023). Assessing Students' Awareness of 4Cs Skills after Mobile-Technology-Supported Inquiry-Based Learning. *Sustainability (Switzerland)*, *15*(8). https://doi.org/10.3390/su15086725
Lu, K., Pang, F., & Shadiev, R. (2021). Understanding the mediating effect of learning approach between learning factors and higher order thinking skills in collaborative inquiry-based learning. *Educational Technology Research and Development*, *69*(5), 2475–2492. https://doi.org/10.1007/s11423-021-10025-4
Pratiwi, S. N., Cari, C., Aminah, N. S., & Affandy, H. (2019). Problem-Based Learning with Argumentation Skills to Improve Students' Concept Understanding. *Journal of Physics: Conference Series*, *1155*, 012065. https://doi.org/10.1088/1742-6596/1155/1/012065
Simon, S., Erduran, S., & Osborne, J. (2006). Learning to Teach Argumentation : Research and development in the science classroom. *International Journal of Science Education*, *28*(2–3), 235–260. https://doi.org/10.1080/09500690500336957
Songsil, W., Pongsophon, P., Boonsoong, B., & Clarke, A. (2019). Developing scientific argumentation strategies using revised argument-driven inquiry (rADI) in science classrooms in Thailand. *Asia-Pacific Science Education*, *5*(1). https://doi.org/10.1186/s41029-019-0035-x
Sugeng, B., & Suryani, A. W. (2019). Enhancing the learning performance of passive learners in a financial management class using problem-based learning. *Journal of University Teaching and Learning Practice*, *17*(1). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85079608856&partnerID=40&md5=c2b47472ff20ace7bd35bae0051214a7
Tâm, N. T. M. (2021). Using Problem-based Tasks to Promote Higher-order Thinking Skills for TESOL MA Students in Vietnam. *Interdisciplinary Journal of Problem-Based Learning*, *15*(1). https://doi.org/10.14434/ijpbl.v15i1.28772
Tama, N. S., Aisyah, N., Santoso, B., & Kurniadi, E. (2020). Learning higher-order thinking skills using problem-based learning model. *Journal of Physics: Conference Series*, *1480*(1). https://doi.org/10.1088/1742-6596/1480/1/012008
Tong, L. C., Rosli, M. S., & Saleh, N. S. (2022). Enhancing HOTS using Problem-Based Learning and Digital Game in the Context of Malaysian Primary School. *International Journal of Interactive Mobile Technologies*, *16*(2), 101–112. https://doi.org/10.3991/ijim.v16i02.27677
Vygotsky, L. S. (1978). *Interaction Between Learning and Development*. W. H Freeman and Company.
Yulianti, E., Pratiwi, N., Mustikasari, V. R., Putri, A. P., Hamimi, E., & Rahman, N. F. A. (2020). Evaluating the effectiveness of problem-based learning in enhancing students' higher order thinking skills. In H. Habiddin, S. Majid, I. Suhadi, N. Farida, & I. W. Dasna (Eds.), *AIP Conference Proceedings* (Vol. 2215). American Institute of Physics Inc. https://doi.org/10.1063/5.0000638