



# The effectiveness of a chemistry teaching module based on local wisdom of fermentation in enhancing students' Higher Order Thinking Skills (HOTS) on acid base material

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## ABSTRACT

The low level of students' higher-order thinking skills in chemistry learning, particularly acid-base material, indicates the need for innovative, contextual and meaningful teaching materials. This study aims to develop and test the effectiveness of a chemistry teaching module based on local fermentation wisdom in improving students' Higher-Order Thinking Skills (HOTS) in the implementation of the Independent Curriculum. The study used a Research and Development approach with a four-stage model, focusing on the development stage. The module's effectiveness was tested through a quasi-experimental design with a single pretest and posttest group involving eleventh-grade students. Data were collected using a HOTS test based on the local fermentation context and an observation sheet of learning implementation, then analyzed descriptively and inferentially. The results showed that the developed module was classified as very practical and easy to implement in learning. This module was also effective in improving students' HOTS, with the most prominent improvements in analytical and evaluation skills, as well as significant improvements in creative abilities. These findings indicate that the local fermentation wisdom-based module can be an alternative contextual teaching material to support students' HOTS development.



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## INTRODUCTION

Education under the *Kurikulum Merdeka* (Independent Curriculum) necessitates innovation in teaching materials that are not only capable of delivering content but also effectively developing Higher Order Thinking Skills (HOTS) in students (Sappaile et al., 2024). These skills, which encompass the abilities to analyze, evaluate, and create, are becoming crucial competencies for facing 21st-century challenges (Anderson et al., 2023). In chemistry learning, HOTS is manifested in the student's ability to analyze chemical data, evaluate experimental results, and synthesize solutions to contextual problems, such as determining the quality of fermented products based on pH and acid-base equilibrium (Santoso et al., 2021).

However, data from the Programme for International Student Assessment (PISA) in 2022 indicates that Indonesian students' scientific literacy remains at a low rank, suggesting difficulty in solving problems that demand high-level reasoning (OECD, 2023). This phenomenon is also reflected in chemistry learning, where the abstract nature of material, such as the concept of acid and base, often becomes an obstacle for students to achieve deep conceptual and applicative understanding (Utami et al., 2020). One of the reasons for the low attainment of HOTS is the dominance of conventional teaching materials which primarily focus on the mastery of basic concepts and have not optimally bridged the gap between theory and the students' real-life context (Chun & Abdullah, 2019; Kamilia, 2025).

In response to this issue, several studies have explored the use of local context and local wisdom as a strategy to enhance chemistry learning outcomes. Research by Bortnik et al. (2021) and Minata et al. (2022) demonstrated that context-based chemistry instruction grounded in local phenomena can significantly improve students' conceptual understanding and analytical skills. Similarly, Irhasyurna

et al. (2022) reported that the integration of local wisdom in science learning fosters students' critical thinking and engagement. These studies collectively confirm that local context can function as an effective bridge between abstract scientific concepts and students' lived experiences.

However, a closer examination of previous research reveals several important limitations. First, most existing studies emphasize improvements in conceptual understanding and analytical skills (C4), while relatively few explicitly investigate higher cognitive dimensions such as evaluation (C5) and creation (C6). Zainuddin et al. (2025), for instance, found that contextual learning tends to produce stronger gains in analysis than in evaluation or creativity. Second, in many studies, local wisdom is positioned primarily as an illustrative example or supporting context, rather than being systematically embedded into the learning syntax and assessment instruments designed to train HOTS. Third, research focusing specifically on acid–base material within the framework of the Kurikulum Merdeka and using local fermentation phenomena as the core learning context remains limited.

Addressing these gaps and to address the challenge of students' low higher-order thinking skills in chemistry, this study developed and tested the effectiveness of an innovative chemistry teaching module that systematically integrates local wisdom into acid-base material. This research stems from the need for contextual and meaningful teaching materials, aligned with the Merdeka Curriculum (Independent Curriculum), which provides flexibility for educators to utilize local potential as learning resources. The integration of local context is expected to bridge the gap between abstract chemistry concepts and students' real-life experiences.

The local wisdom explored in this study is the fermentation phenomenon developing in Bintan Regency, such as the production of cencalok (rice cake), bekasam (rice cake), tapai (tapai), and pineapple vinegar. This context serves as the primary context for learning the concepts of acid-base, equilibrium, and pH determination (Riza et al., 2020). This context serves as a concrete bridge, enabling students to connect theoretical concepts with everyday phenomena they are familiar with. This approach is based on constructivism theory, which emphasizes that learning is more effective when new knowledge is constructed through students' real-life experiences and environments (Liliasari et al., 2018).

The novelty of this research lies in the development of a chemistry teaching module based on local fermentation wisdom, specifically designed to train higher-order thinking skills at the levels of analysis, evaluation, and creation in a single learning unit. Unlike previous studies that generally position local wisdom as an illustration or supporting context, this module integrates the fermentation phenomenon completely into the learning syntax and HOTS evaluation instruments. Thus, this research not only enriches the study of contextual learning but also provides an innovative teaching material model that is relevant, applicable, and oriented towards the development of students' HOTS.

Therefore, the primary objective of this research is to develop and test the effectiveness of the Chemistry Teaching Module based on fermentation local wisdom in enhancing students' HOTS on acid-base material. Specifically, this study seeks to determine the level of effectiveness in improving each cognitive dimension of HOTS (Analysis, Evaluation, and Creation). This study is part of a series of Research and Development (R&D) studies using the 4D model (Define, Design, Develop, Disseminate), with this article focusing on the Develop stage to measure the module's effectiveness. The effectiveness test was conducted through a quasi-experimental One Group Pretest-Posttest design involving 35 students. The contribution of this research is to provide strong empirical evidence regarding the integration of local wisdom as a contextual and effective chemistry learning strategy for achieving the improvement of Higher Order Thinking Skills mandated by the *Kurikulum Merdeka*.

## RESEARCH METHODS

This research is a Research and Development (R&D) project using the 4D model, which includes defining, designing, developing, and disseminating the stages (Irawan et al., 2018). This article focuses on the development stage, specifically testing the effectiveness of a local wisdom-based chemistry teaching module on fermentation. The effectiveness test was conducted using a quasi-

experimental design with a single-group pretest-posttest to assess improvements in students' higher-order thinking skills (HOTS) after implementing the module on acid-base material (Chang et al., 2022).

The research was conducted at SMAN 1 Teluk Sebong, Bintan Regency, Riau Islands Province, during the odd semester of the 2025/2026 academic year. The study population was all 11th-grade students, with a purposively selected sample of 35 students from one class. Sample selection was based on the need to improve HOTS skills in acid-base material and the relevance of local wisdom in fermentation as a learning context. The learning process was carried out by a chemistry teacher, supported by observations to ensure the module's implementation in accordance with the learning plan.

Data collection was conducted using a HOTS test based on the local fermentation context administered before and after the intervention, as well as an observation sheet for learning implementation. Data were analyzed quantitatively through descriptive and inferential analysis. HOTS improvement was analyzed using a paired sample t-test or Wilcoxon test, depending on the results of the data normality test, with a significance level of 0.05. The module's effectiveness was determined based on the N-Gain value, while the strength of the learning influence was analyzed using Cohen's d effect size. A module is considered effective if it is able to improve students' HOTS in the moderate to high category.

## RESULTS AND DISCUSSION

### Results

The implementation of the chemistry teaching module based on local fermentation wisdom was evaluated through three sets of data: observation of teacher implementation, observation of student activities, and the HOTS test (pretest-posttest).

#### Teacher Instructional Implementation

Observation of the teacher across four meetings aimed to ensure that the module implementation proceeded according to the design. The results of the data recapitulation (Table 1) indicate an average implementation percentage of 92.19%, which falls into the "Very Good" category. There was an increasing trend in implementation fidelity from the first meeting (88.75%) to the peak third meeting (95.00%).

**Table 1. Findings from the Observation of Teacher Learning Implementation**

No	Indikator	Observer Findings for Session			
		No.			
		1	2	3	4
1	Did the teacher execute the instructional stages (opening, core, and closing) sequentially as prescribed by the teaching module?	4	5	5	5
2	Did the teacher implement the learning model steps (syntax) as per the teaching module to solve the contextual fermentation problem?	4	4	5	5
3	Did the teacher communicate the learning objectives that target analytical/evaluative abilities and their achievement criteria?	5	5	5	5
4	Did the teacher utilize the local fermentation phenomenon to connect students' prior knowledge with the acid-base concept?	5	5	5	5
5	Did the teacher facilitate activities that actively challenge students to analyze and evaluate problems?	4	4	5	5
6	Did the teacher guide students to draw conclusions about the acid-base chemistry concepts from the	4	5	5	5

No	Indikator	Observer Findings for Session			
		No.			
		1	2	3	4
	contextual activities?				
7	Did the teacher manage the time allocation effectively so that all learning stages were executed according to the teaching module?	5	4	4	5
8	Did the teacher encourage active discussion and prompt critical questions from the students?	4	5	5	4
9	Did the teacher use clear, easily understandable language, and precise chemical terminology?	5	5	5	5
10	Did the teacher facilitate students to collaborate in groups and present their analysis results?	5	4	5	4
11	Did the teacher monitor students' understanding during the learning process through oral questions or short quizzes?	4	4	4	5
12	Did the teacher provide problems or assignments at the end of the session that measure analytical (C <sub>4</sub> ) or evaluative (C <sub>5</sub> ) abilities?	4	5	5	5
13	Did the teacher guide students to reflect on the thought processes they used when solving problems?	4	4	4	4
14	Did the teacher integrate and provide feedback on the dimensions of the graduate profile?	4	4	5	4
15	Did the teacher provide support or additional challenges according to the identified learning needs of the students?	5	5	4	4
16	Did the teacher primarily guide the discovery of concepts rather than giving direct explanations?	5	5	5	5
	Total Score	71	73	76	75
	Percentage	88.75%	91.25%	95.00%	93.75%
	Average Percentage	92.19%			

Source: (Data Processing, 2025)

### Student Activity Observation

Concurrently, observation of student activities was conducted to measure their response and engagement. The results in Table 2 indicate that the average percentage of student activity reached 88.44% (categorized as "Very Good"). Student engagement also demonstrated a consistent increasing trend, from 82.50% in the first meeting to 93.75% in the final meeting.

**Table 2. Results of Student Activity Observation**

No	Indikator	Observer Findings for Session No.			
		1	2	3	4
1	Did the students actively ask questions, answer questions, and convey ideas in the class discussion?	4	4	5	5
2	Did the students show high interest and curiosity toward the presented local fermentation context?	5	5	5	5
3	Were the students fully engaged in the learning activities and focused on the assigned tasks?	4	4	5	5
4	Did the students ask profound questions (why/how) to understand the problem, not just factual questions?	4	4	4	5

No	Indikator	Observer Findings for Session No.			
		1	2	3	4
5	Were the students able to identify key information and relevant data from the presented case studies or problems?	4	4	5	5
6	Were the students able to provide logical reasons or evidence to support the opinions or solutions they proposed?	4	4	4	4
7	Did the students actively contribute, share tasks, and discuss to achieve the group's objectives?	4	5	5	4
8	Did the students listen and respond to their group members' ideas constructively and respectfully?	5	5	5	5
9	Were the students able to present the results of their discussions or group findings clearly and systematically?	4	4	5	5
10	Did the students show persistence and try various strategies to solve the given problem?	4	4	4	5
11	Were the students able to identify concepts already understood and parts that were still difficult during the reflection session?	4	4	4	4
12	Were the students able to explain the connection between the activity (fermentation) and the acid-base chemistry concepts?	4	4	5	5
13	Did the students actively use the learning resources (student worksheets, reading materials, and assessments) from the teaching module as the main guide in the activities?	5	5	5	5
14	Did the students show initiative in seeking information or starting discussions without always being directed by the teacher?	4	4	4	4
15	Did the students demonstrate responsibility in completing their task portions, both individually and in groups?	5	5	5	5
16	Did the students attempt to offer different (creative) ideas or solution approaches during the discussion?	3	3	4	4
Total Score		66	68	74	75
Percentage		82.50%	85.00%	92.50%	93.75%
Average Percentage		88.44%			

Source: (Data Processing, 2025)

### Improvement in Higher Order Thinking Skills (HOTS)

The effectiveness of the module in enhancing HOTS was measured quantitatively through the pretest and posttest administered to 35 students. Descriptive statistical analysis (Table 3) shows a substantial increase in the mean score from 24.86 (SD = 18.845) to 72.29 (SD = 11.137).

**Table 3. HOTS Pretest-Posttest Descriptive Statistics**

	N	Minimum	Maximum	Mean	Std. Deviasi
Pretest	35	0	50	24,86	18,845
Posttest	35	60	90	72,29	11,137
Valid N (listwise)	35				

Source: (Data Processing, 2025)

**Table 4. Pretest and Posttest Data Normality Analysis**

	Shapiro-Wilk		
	Statistic	Df	Sig (p)
Pretest	0,874	35	<0,001
Posttest	0,833	35	<0,001

Source: (Data Processing, 2025)

**Table 5. Wilcoxon Signed Ranks Test**

Ranks			Test Statistics <sup>a</sup>			
		N	Mean Rank	Sum of Ranks	of	Posttest - Pretest
Posttest	- Negative Ranks	0 <sup>a</sup>	0,00	0,00	Z	-5,210 <sup>b</sup>
Pretest	Positive Ranks	35 <sup>b</sup>	18,00	630,00	Asymp. Sig. (2-tailed)	0,000
	Ties	0 <sup>c</sup>				
	Total	35				

a. Posttest < Pretest

b. Posttest > Pretest

c. Posttest = Pretest

Source: (Data Processing, 2025)

The results of the Shapiro-Wilk normality test indicated that the data were not normally distributed ( $p < 0.05$ ), thus the hypothesis was tested using the Wilcoxon Signed-Rank Test. The results showed a highly statistically significant difference between the pretest and posttest scores ( $Z = -5.203$ ,  $p < .001$ ). The magnitude of the intervention's impact was classified as large (effect size  $r = 0.88$ ). Furthermore, the Normalized Gain (N-Gain) analysis showed a mean score of 0.639, which indicates that the effectiveness level of HOTS enhancement is in the "Moderate" category.

**Table 6. Normalized Gain**

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
NGainscore	35	0,40	0,83	0,6385	0,10529
Valid (listwise)	N 35				

Source: (Data Processing, 2025)

To analyze the module's effectiveness in greater depth, the Normalized Gain (N-Gain) was calculated for each cognitive level of HOTS ( $C_4$ ,  $C_5$ ,  $C_6$ ). The results are presented in Table 7 below.

**Table 7. Results of the N-Gain Analysis Based on HOTS Cognitive Level**

Cognitive Level	Average Pretest Score	Average Posttest Score	N-Gain	Category
Analysis ( $C_4$ )	28.50	78.10	0.70	High
Evaluation ( $C_5$ )	22.15	71.55	0.63	Moderate
Creation ( $C_6$ )	15.20	58.75	0.51	Moderate

Source: (Data Processing, 2025)

## Discussion

The main findings of this research convincingly demonstrate that the use of a chemistry teaching module based on local fermentation wisdom is highly effective in enhancing students' HOTS. This statistically significant increase ( $p < 0.001$ ), coupled with a large effect size ( $r = 0.88$ ) and a "Moderate" effectiveness level (N-Gain = 0.639), can be attributed to the successful implementation of the instructional design in the classroom.

This success is inseparable from the high quality of the learning process, as validated by the observation data. The teacher implementation rate reaching 92.19% confirms that the instructional syntax (modified inquiry) designed to stimulate HOTS was well-implemented. High fidelity in implementation ensured that the teacher provided appropriate scaffolding to guide students from recognizing the contextual problem to formulating high-level solutions. This served as the foundation for creating a conducive learning environment, which students responded to positively with an engagement level reaching 88.44%. The use of a familiar local context, such as *cencalok* production, likely boosted students' self-efficacy, making the chemistry problems less intimidating and increasing their motivation to actively participate (Minata, ZS., Rahayu, S., Dasna, 2022; Salvane & Orongan, 2024).

Specifically, this success was driven using the local fermentation context, which proved capable of consistently stimulating students' enthusiasm and curiosity. This finding aligns with the principles of contextual learning, which suggest that material relevant to the students' world can increase motivation and deeper understanding (Kemendikdasmen, 2025). The fermentation process acted as a concrete analog, bridging the gap between the abstract concepts of acid-base equilibrium and the real-world application, which is crucial for achieving C<sub>4</sub> (Analysis) and C<sub>5</sub> (Evaluation) skills.

The detailed analysis of cognitive levels (Table 7) confirms that the highest increase occurred in the Analysis (C<sub>4</sub>) domain (N-Gain = 0.70), which relates to students' ability to analyze pH data and chemical reactions within the fermentation case studies. Evaluation (C<sub>5</sub>), which represented 60% of the test items, was also highly effective (N-Gain = 0.63), demonstrating the students' strong ability to evaluate claims and assess the quality of fermented products. The lowest increase was found in the Creation (C<sub>6</sub>) domain (N-Gain = 0.51). This suggests that while the module successfully trained students to analyze and evaluate existing information, the activities might not have provided sufficient open-ended tasks or project opportunities necessary for optimal synthesis and creation of new ideas, which is a common challenge in developing the highest level of HOTS. This deficiency in the C<sub>6</sub> indicator serves as a clear limitation and suggests a direction for future module refinement.

Furthermore, the student observation data directly indicate the occurrence of higher-order thinking processes during instruction. The increase in scores on indicators like "asking critical questions" and "analyzing information" suggests that the activities designed within the module successfully prompted students to move beyond the level of factual comprehension. This explains the substantial jump in the posttest mean score (72.29) from the pretest score (24.86). Overall, this study provides strong empirical evidence that integrating local fermentation wisdom into a HOTS-oriented chemistry teaching module is a highly effective strategy. This finding contributes practically by providing a validated teaching material model that can be adopted by teachers to implement innovative learning in accordance with the demands of the *Kurikulum Merdeka*.

This research is significant because it addresses the real needs of chemistry learning in the Independent Curriculum era, particularly in improving students' HOTS (Higher-Skilled Skills) through contextualized and relevant teaching materials. Low HOTS is often caused by the dominance of abstract approaches and the lack of connection between chemical concepts and students' daily lives (Rahayu & Rosawati, 2023; Tsaparlis, 2020). By integrating local wisdom about fermentation, this research offers a pedagogical solution that not only improves high-level cognitive achievement but also strengthens students' learning meaning, motivation, and self-efficacy. Therefore, this research makes an important contribution to bridging the demands of curriculum policy with applicable and sustainable chemistry learning practices.

The findings of this study align with those of Bortnik et al. (2021) and Minata et al. (2022), which showed that local context-based chemistry learning significantly improves students' conceptual understanding and analytical skills. The similarity lies in the role of local context as a concrete bridge to understanding abstract chemical concepts. Furthermore, this research also supports the findings of Irhasyuarna et al. (2022), who reported that integrating local wisdom into science learning positively contributes to improving critical thinking skills and active student engagement. This alignment strengthens the argument that local context is not merely a supplement, but a strategic component in HOTS development.

Furthermore, this study demonstrates a relatively higher level of reinforcement in the evaluation aspect (C5) compared to several previous studies, such as those reported by Zainuddin et al. (2025), who found that contextual learning predominantly improves analytical skills compared to evaluation and creativity. This difference is likely due to the module design in this study, which explicitly places evaluative activities, such as assessing the quality of fermented products and testing scientific claims, at the core of learning. Thus, this study extends previous findings by demonstrating that HOTS at the evaluation level can be optimally developed through appropriate task design.

Despite showing strong results, this study has several limitations. First, the study design used a single group without a control group, so generalization of the findings requires caution. Second, the number of subjects was limited to one school and one local fermentation context, so the module's effectiveness in other cultural contexts cannot be confirmed. Third, improvement in the Creativity domain (C6) is still lower than in other HOTS domains, indicating that learning activities do not fully provide space for open exploration, independent projects, or the design of innovative solutions by students. This limitation opens up opportunities for further research to develop modules with project-based or open-ended problem-based assignments to optimize creativity skills as the highest level of HOTS.

The implications of these findings lead to two main recommendations. For educational practitioners, especially chemistry teachers, this teaching module is highly recommended for adoption and adaptation as an innovative and contextual strategy to train Higher Order Thinking Skills (HOTS) in line with the demands of the *Kurikulum Merdeka*. However, based on the C<sub>6</sub> results, teachers are specifically advised to integrate or replace the existing C<sub>6</sub> assignments with open-ended tasks or mini-projects (e.g., designing an improved fermented product) to maximize the synthesis and creative abilities of the students. Furthermore, for future researchers, this study opens opportunities for further development, primarily by employing a more robust research design, such as a true experimental design that includes a control group, to strengthen the generalization and internal validity of the findings. Future research should also explore the use of mixed methods approaches to more comprehensively capture the depth of the Creation (C<sub>6</sub>) skill, given the limitations identified with the multiple-choice format.

## CONCLUSION

Based on the research findings and discussion, it is concluded that the developed chemistry teaching module based on local fermentation wisdom successfully achieved the research objectives. The module is proven to be highly effective in enhancing students' Higher Order Thinking Skills (HOTS), evidenced by a statistically significant difference between the pretest and posttest scores ( $p < 0.001$ ) with a large effect size ( $r = 0.88$ ). This success is supported by the module's high validity and practicality in the field, as seen from the teacher implementation score (92.19%) and active student involvement (88.44%). The magnitude of the HOTS improvement, measured via N-Gain, falls into the "Moderate" category (0.639). Crucially, the detailed analysis by cognitive level confirms the module's strong impact on Analysis (C<sub>4</sub>) with a "High" category (N-Gain = 0.70) and Evaluation (C<sub>5</sub>) with a "Moderate" category (N-Gain = 0.63). Although the Creation (C<sub>6</sub>) domain also improved (N-Gain = 0.51), this study indicates that the module is primarily effective in fostering the analytical and evaluative dimensions of HOTS.

## REFERENCES

- Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2023). *Taksonomi Anderson (et.al.): Revisi atas Taksonomi Bloom (et.al.)*. 323.
- Bortnik, B., Stozhko, N., & Pervukhina, I. (2021). Context-based testing as assessment tool in chemistry learning on university level. *Education Sciences*, 11(8), 450. <https://doi.org/10.3390/educsci11080450>
- Chang, S. J., Lee, K., Yang, E., & Ryu, H. (2022). Evaluating a theory-based intervention for improving eHealth literacy in older adults: a single group, pretest–posttest design. *BMC Geriatrics*, 22(1), 918. <https://link.springer.com/article/10.1186/s12877-022-03545-y>
- Chun, T. C., & Abdullah, M. N. L. Y. B. (2019). The teaching of higher order thinking skills (HOTS) in Malaysian schools: Policy and practices. *MOJEM: Malaysian Online Journal of Educational Management*, 7(3), 1–18. <https://tamilperaivu.um.edu.my/index.php/MOJEM/article/view/18591>
- Irawan, A. G., nyoman Padmadewi, N., & Artini, L. P. (2018). Instructional materials development through 4D model. *SHS Web of Conferences*, 42, 86. [https://www.shs-conferences.org/articles/shsconf/abs/2018/03/shsconf\\_gctale2018\\_00086/shsconf\\_gctale2018\\_00086.html](https://www.shs-conferences.org/articles/shsconf/abs/2018/03/shsconf_gctale2018_00086/shsconf_gctale2018_00086.html)
- Irhasyuarna, Y., Kusasi, M., Fahmi, F., Fajeriadi, H., Aulia, W. R., Nikmah, S., & Rahili, Z. (2022). Integrated science teaching materials with local wisdom insights to improve students' critical thinking ability. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, 4(3), 328–334. <https://ppjp.ulm.ac.id/journal/index.php/bino/article/view/14148>
- Kamilia, L. (2025). Analisis Soal HOTS Materi Asam Basa Untuk Mengukur Keterampilan Berpikir Kritis Dengan Rasch. *Jurnal Matematika Dan Ilmu Pengetahuan Alam*, 3(1), 99–111. <https://doi.org/https://doi.org/10.62383/pentagon.v3i1.411>
- Kemendikdasmen. (2025). *Panduan Pembelajaran STEM*. BSKAP Kemendikdasmen.
- Liliasari, S., Albaiti, A., & Wahyudi, A. (2018). Calcium contained tap water phenomena: Students misconception patterns of acids-bases concept. *Journal of Physics: Conference Series*, 1013(1), 2–7. <https://doi.org/10.1088/1742-6596/1013/1/012095>
- Minata, ZS., Rahayu, S., Dasna, I. W. (2022). Context-Based Chemistry Learning: A Systematic Literature Review. *Jurnal Pendidikan*, 23(October), 1446–1463. <https://doi.org/http://dx.doi.org/10.23960/jpmipa/v23i4.pp1446-1463>
- Minata, Z. S., Rahayu, S., & Dasna, I. W. (2022). Context-Based Chemistry Learning: A Systematic Literature Review. *Jurnal Pendidikan MIPA*, 23(4), 1446–1463. <https://jpmipa.fkip.unila.ac.id/index.php/jpmipa/article/view/583>
- OECD. (2023). PISA 2022 Results Factsheets Indonesia. *OECD (Organisation for Economic Co-Operation and Development) Publication*, 1–9.
- Rahayu, S., & Rosawati, E. E. (2023). The development of higher-order thinking skills (HOTS) assessment instrument in chemistry using socioscientific issues context: A preliminary trial. *AIP Conference Proceedings*, 2572(1), 30009. <https://doi.org/10.1063/5.0118624>
- Riza, M., Firmansyah, R. A., Zammi, M., & Djuniadi, D. (2020). Pengembangan modul kimia berbasis kearifan lokal Kota Semarang pada materi larutan asam dan basa. *Jurnal Pendidikan IPA Veteran*, 4(1), 25–38.
- Salvane, C. F., & Orongan, M. J. (2024). Performance, Conceptual Understanding, and Self-Efficacy of Students via Contextualized Self-learning Modules in Junior High School: Performance, Conceptual Understanding, and Self-Efficacy of Students. *International Journal of Curriculum and Instruction*, 16(1), 107–128. <https://ijci.net/index.php/IJCI/article/view/1417>

- Santoso, A. M., Primandiri, P. R., Zubaidah, S., & Amin, M. (2021). The development of students' worksheets using project based learning (PjBL) in improving higher order thinking skills (HOTS) and time management skills of students. *Journal of Physics: Conference Series*, 1806(1). <https://doi.org/10.1088/1742-6596/1806/1/012173>
- Sappaile, B. I., Wiliyanti, V., Mustajab, W., Prayitno, H., & Panglipur, I. R. (2024). Building the Future of Education with Curriculum Innovation Freedom to Learn in the Era of Society 5.0. *International Journal of Educational Research Excellence (IJERE)*, 3(1), 359–366. <https://doi.org/10.55299/ijere.v3i1.902>
- Tsaparlis, G. (2020). Higher and lower-order thinking skills: The case of chemistry revisited. *Journal of Baltic Science Education*, 19(3), 467–483. <https://www.ceeol.com/search/article-detail?id=946687>
- Utami, F. V., Saputro, S., & VH, E. S. (2020). Analisis Jenis Dan Tingkat Kesulitan Belajar Siswa Kelas Xi Mipa Sma N 2 Surakarta Tahun Pelajaran 2018 / 2019 Dalam Memahami Materi Asam Basa Menggunakan Two Tier Multiple Choice. *Jurnal Pendidikan Kimia*, 9(1), 54–60. <https://doi.org/https://doi.org/10.20961/jpkim.v9i1.33860>
- Zainuddin, Z., Nafisah, A., & Muttaqin, M. (2025). Transforming Character Education through the Implementation of the Independent Curriculum in Indonesia. *International Journal of Education and Humanities*, 5(3), 560–572. <http://i-jeh.com/index.php/ijeh/article/view/346>