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ENHANCING CHEMISTRY LITERACY THROUGH PROJECT-BASED WORKSHEETS ON PINEAPPLE PEEL-BASED BODY LOTION PRODUCTION IN SENIOR HIGH SCHOOL STUDENTS

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ABSTRACT

Abstract: This study aimed to analyze the improvement of chemistry literacy among Grade XI students (n = 17) at MA Al Jawami, Bandung, through project-based worksheets utilizing pineapple peel waste extract in body lotion production. A pre-experimental one-group pretest–posttest design was applied. The learning process followed six Project-Based Learning stages: identifying problems, designing the project, conducting investigation, developing a product prototype, testing and improving the product, and finalizing and presenting the product. Data were collected using a validated 10-item chemistry literacy test (Aiken's V = 0.89; Cronbach's α = 0.85), observation sheets, and a scientific attitude questionnaire. Data analysis used descriptive statistics, Shapiro–Wilk test, Wilcoxon Signed-Rank Test, and normalized gain (N-gain). The results showed a significant improvement in chemistry literacy ($Z = -3.684$, $p < .001$; $r = 0.89$), with a high N-gain of 0.86. The highest gain occurred in the process dimension, while the lowest was in the attitude dimension. These findings indicate that project-based worksheets support contextual chemistry learning.

Abstrak: Penelitian ini bertujuan untuk menganalisis peningkatan literasi kimia siswa kelas XI MA Al Jawami, Bandung (n = 17) melalui penerapan lembar kerja berbasis proyek dengan pemanfaatan ekstrak limbah kulit nanas dalam pembuatan *body lotion.* Penelitian menggunakan desain pre-eksperimen *one-group pretest–posttest.* Pembelajaran dilaksanakan melalui enam tahap Project-Based Learning, yaitu identifikasi masalah, perancangan proyek, investigasi, pengembangan prototipe produk, pengujian dan penyempurnaan produk, serta finalisasi dan presentasi produk. Data dikumpulkan menggunakan tes literasi kimia terstandar sebanyak 10 butir soal (Aiken's V = 0,89; Cronbach's α = 0,85), lembar observasi, dan angket sikap ilmiah. Analisis data menggunakan statistik deskriptif, uji *Shapiro–Wilk, Wilcoxon Signed-Rank Test*, dan N-gain. Hasil penelitian menunjukkan peningkatan literasi kimia yang signifikan (Z = −3,684; p < 0,001; r = 0,89) dengan *N-gain* tinggi sebesar 0,86. Peningkatan tertinggi terdapat pada aspek proses, sedangkan terendah pada aspek sikap. Temuan ini menunjukkan bahwa lembar kerja berbasis proyek mendukung pembelajaran kimia kontekstual.

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INTRODUCTION

The low level of students' scientific literacy remains a major challenge in Indonesian science education. This is reflected in the Programme for International Student Assessment (PISA) 2022, which ranked Indonesia 68th out of 81 countries with a science score of 383, well below the OECD average of 485 (OECD, 2023), underscoring the need to strengthen students' ability to apply scientific knowledge in real-life contexts (Bilad et al., 2024). In chemistry education specifically, students continue to struggle with connecting chemical concepts to contextual problems and applying scientific reasoning in problem solving (Wardani et al., 2024 ;Pane et al., 2024) a pattern commonly linked to instruction that emphasizes memorization over meaningful conceptual understanding (Mellyzar et al., 2022;Aisyah & Wiyarsi, 2025).

Chemistry literacy is a central goal of chemistry education, encompassing chemical content knowledge, chemistry in context, higher-order thinking skills, and affective dimensions (Shwartz et al., 2006). It is commonly operationalized into four dimensions content, context, process, and attitude representing conceptual understanding, real-world application, scientific inquiry skills, and scientific dispositions, respectively (Cigdemoglu & Geban, 2015). Developing chemistry literacy enables students to interpret scientific phenomena and make informed decisions (Wardani et al., 2024) and supports the growth of environmental awareness and scientific agency (Sjöström et al., 2024) Recent studies suggest that contextual, project-based, and STEM-integrated instruction can strengthen chemistry literacy by engaging students in scientific inquiry and authentic problem solving (Amdayani et al., 2025; Sulastri & Fatimah, 2024; Manik et al., 2024).

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Project-Based Learning (PjBL), supported by project-based worksheets, is an instructional approach well suited to this purpose. Structured through problem identification, project planning, investigation, product development, evaluation, and dissemination stages(Yasinta et al., 2023),Click or tap here to enter text. PjBL promotes active learning, collaboration, creativity, and problem-solving while allowing students to construct chemical knowledge through authentic experience (Mubarok et al., 2025;Susanti et al., 2024). Systematic reviews confirm that PjBL positively influences students' engagement, conceptual understanding, and higher-order thinking in chemistry education(Almulla, 2020;Pratiwi & Ikhsan, 2024; Lethulur et al., 2025).

Indonesia's substantial pineapple *(Ananas comosus L.)* production 3,156,567 tons in 2023 (BPS, 2024) generates large volumes of peel waste, roughly 30% of total fruit mass, which is commonly discarded despite containing bioactive compounds such as vitamin C, flavonoids, carotenoids, bromelain, and phenolic compounds with antioxidant and antimicrobial properties(Hernández-Montesinos et al., 2024). Utilizing this waste supports circular bioeconomy practices(Paz-Arteaga et al., 2024) and offers an authentic, real-world medium for chemistry instruction (Martín-Alfonso & Yáñez, 2024),including as an ingredient in body-lotion formulation, a colloidal (emulsion) system directly relevant to the senior-high chemistry curriculum.

Although prior studies have explored project-based chemistry learning through various contextual media such as hand cream production (Delima et al., 2025), edible film production (Khoirunnisa et al., 2025),ethnochemistry integration (Wardani et al., 2024),and scientific-literacy-oriented worksheets (Rahmi et al., 2024) few have used pineapple peel waste as a learning context, and fewer still have measured its effect comprehensively across all four chemistry-literacy dimensions (content, context, process, and attitude) within a single instructional intervention. Research situated in Islamic senior high school (madrasah) settings remains particularly scarce. Therefore, this study analyzes the improvement of Grade XI students' chemistry literacy at MA Al Jawami through the implementation of a project-based worksheet on body lotion production from pineapple peel extract, delivered through six PjBL stages: problem identification, project design, investigation, product development, evaluation, and dissemination. The following section describes the pre-experimental design, participants, instruments, and analytical procedures used to address this objective.

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METHOD

Research Design

This study employed a pre-experimental one-group pretest–posttest design to examine the change in students' chemistry literacy associated with a project-based worksheet on body lotion production from pineapple peel extract (Sugiyono, 2023).One experimental group received the Project-Based Learning (PjBL) treatment, with pretest and posttest administered to measure change before and after the intervention. The design is presented in Table 1.

Table 1. One-Group Pretest–Posttest Design

Pretest	Treatment	Posttest
O_1	X	O_2

We acknowledge that this design is inherently limited in establishing causality: without a control or comparison group, the observed pretest–posttest change cannot be attributed solely to the project-based worksheet, since maturation, testing effects, or other classroom factors cannot be ruled out. This design was chosen because of practical constraints of working within a single available intact class at the research site; findings are therefore reported as preliminary, classroom-based evidence of association rather than a definitive causal effect. Future studies are recommended to adopt a quasi-experimental design (e.g., non-equivalent control group design) or a randomized controlled trial to strengthen internal validity.

Participants

The study involved 17 Grade XI (Science) students at MA Al Jawami during the 2025/2026 academic year, selected through purposive sampling based on prior exposure to colloid-system material and readiness to participate in project-based learning activities; this reflected the single intact class available at the school that met these criteria. Students were randomly assigned into four project groups. Given the small sample size, findings should not be generalized beyond similar classroom contexts, and results are best interpreted as preliminary evidence pending replication with larger, more diverse samples.

Ethical considerations: prior to data collection, the researchers obtained formal research permission from the school and informed consent from participating students and their parents/guardians, including for the documentation used in Figures 1 and 2. For the final published version, identifiable student faces in laboratory-activity photographs should be cropped, blurred, or accompanied by explicit media-release consent to protect participants' privacy.

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Research Instruments

Five main instruments were used. (1) The project-based worksheet (LKPD) guided students through the six PjBL stages and embedded a 1–3 scoring rubric for each stage. (2) The chemistry literacy test consisted of 10 multiple-choice items, administered individually in 20 minutes for both pretest and posttest, developed from a blueprint (kisi-kisi) distributing items across the content, context, process, and attitude dimensions on the topic of colloid systems, emulsification, and the physicochemical properties of body lotion. (3) The scientific attitude questionnaire comprised 10 Likert-scale statements covering curiosity, responsibility, cooperation, objectivity, and openness to others' opinions. (4) A structured observation sheet recorded student activity across the six PjBL stages. (5) Product, presentation, and poster assessment rubrics evaluated the resulting body lotion (organoleptic quality, pH suitability, homogeneity, and consistency), oral presentation, and project poster, respectively.

All instruments were reviewed by three validators two chemistryeducation lecturers from UIN Sunan Gunung Djati Bandung and one chemistry teacher at MA Al Jawami who assessed content, construction, and language aspects. Instruments were revised according to validator feedback prior to use. Content validity of the chemistry literacy test yielded an Aiken's V of 0.89 (high validity), and reliability testing produced a Cronbach's alpha of 0.85 (good reliability).

Data Analysis

Descriptive statistics summarized pretest, posttest, and observation scores. Data normality was tested using the Shapiro–Wilk test, appropriate for the small sample size ($n < 50$). Because the data were not normally distributed, the non-parametric Wilcoxon Signed-Rank Test was used to test the significance of the pretest–posttest difference at $\alpha = 0.05$. Effect size was calculated as $r = Z/\sqrt{N}$ and interpreted using standard benchmarks (small ≈ 0.10, medium ≈ 0.30, large ≥ 0.50). Normalized gain (N-gain) was calculated for the overall score and for each chemistry-literacy dimension, using Hake's (1999) criteria (high: $g > 0.70$; medium: $0.30 \leq g \leq 0.70$; low: $g < 0.30$). Because each of the four observers rated a different student group rather than co-rating the same group, formal inter-rater reliability (e.g., Cohen's kappa) could not be computed for the observation data; this is noted as a limitation, and future studies are

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encouraged to use overlapping or paired observation to enable reliability estimation.

RESULT AND DISCUSSION

Learning was implemented through a project-based worksheet organized into six structured Project-Based Learning (PjBL) stages: (1) identifying problems, (2) creating a project design, (3) conducting research investigation, (4) compiling a product prototype, (5) measuring and improving the product, and (6) finalising and publishing the product. Within this structured framework, each stage involves both procedural activities and higher-order cognitive processes, enabling students to progressively construct scientific knowledge through active engagement, inquiry, collaboration, and reflective thinking (Khoirunnisa et al., 2025). This structured sequence supported authentic learning because students investigated a real-world problem pineapple peel waste and transformed it into a scientific product, consistent with reports that PjBL integrated with scientific literacy activities enhances engagement, conceptual understandi ng, and scientific reasoning through sustained inquiry-based involvement (Sari et al., 2025). Contextualizing the project around body-lotion production from pineapple peel waste further allowed students to connect chemistry concepts with environmental sustainability issues, supporting meaningful learning that combines theoretical understanding with applied scientific reasoning (Wardani et al., 2024;Sjöström et al., 2024).

Student activity was evaluated using a structured observation sheet across the six PjBL stages, summarized in Table 2.

Table 2. Student Activity Assessment Results on Project-Based Worksheet

No.	Stage	Mean	SD	Max	%	Category
1	Identifying Problems	2.59	0.21	3	86.3	Very Good
2	Creating a Project Design	2.71	0.19	3	90.2	Very Good
3	Conducting Research	2.51	0.18	3	83.7	Good
4	Compiling a Product Prototype	2.85	0.14	3	95.1	Very Good

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No.	Stage	Mean	SD	Max	%	Category
5	Measuring and Improving the Product	2.81	0.16	3	93.5	Very Good
6	Finalising and Publishing the Product	2.76	0.17	3	92.2	Very Good
Overall Average		**2.70**	**0.17**	**3**	**90.2**	**Very Good**

The highest score was found in the product prototype development stage (M = 2.85; SD = 0.14), suggesting stronger engagement in hands-on activities than in conceptual or planning stages, consistent with reports that experiential, hands-on product development strengthens engagement and conceptual clarity (Delima et al., 2025). The product evaluation and improvement stage (M = 2.81) similarly required students to analyze results, identify weaknesses, and revise their product based on evidence, reflecting higher-order, reflective thinking. The dissemination stage (M = 2.76) indicated that students could communicate findings through presentations and reports, an important scientific-communication component of chemistry literacy (Rahmawati et al., 2024).

Laboratory activities during project implementation are shown in Figure 1.

Figure 1. Students' laboratory activities during temperature measurement of pineapple peel extract using thermometer.

The lowest score was found in the research investigation stage (M = 2.51; SD = 0.18), indicating that students experienced greater difficulty during hands-on extraction and formulation, which require precision and

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careful procedural accuracy. Because body lotion is an oil-in-water emulsion (a colloidal system), successful formulation depends on proper phase dispersion; some students had difficulty maintaining consistent stirring, which affected emulsion stability. This stage therefore required both conceptual understanding of colloids and procedural/psychomotor skill, which is demanding for students still adapting to experimental learning. Figure 2 shows the resulting body lotion emulsion.

Figure 2. Body lotion emulsion from pineapple peel extract.

The problem identification stage obtained the highest variability among students (M = 2.59; SD = 0.21), suggesting differences in students' higher-order thinking skills when analyzing contextual environmental problems and linking them to relevant chemistry concepts, consistent with reports that students often find the initial problem-identification stage challenging when integrating prior knowledge with real-world phenomena. Overall, five of the six stages were categorized as "very good," indicating that the structured six-stage worksheet provided adequate scaffolding across the learning cycle, consistent with Khoirunnisa et al. (2025) and Delima et al. (2025)

Prior to hypothesis testing, data normality was examined using the Shapiro–Wilk test (Table 3).

Table 3. Tests of Normality of Pretest and Posttest Data

Data	Statistic	df	Sig.
Pretest	0.856	17	0.013
Posttest	0.579	17	< 0.001

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Both pretest ($p = 0.013$) and posttest ($p < 0.001$) scores deviated from normality, so parametric assumptions were not met. The posttest's marked deviation reflects a clustering of scores near the upper limit after the intervention (a ceiling effect), consistent with most students achieving high outcomes and reduced score variability. Because the normality assumption was violated, the Wilcoxon Signed-Rank Test was used as the non-parametric alternative to the paired-samples t-test, appropriate for related-samples comparisons with small, non-normal data. Results appear in Tables 4 and 5.

Table 4. Wilcoxon Signed Ranks Test

Category	N	Mean Rank	Sum Of Rank
Negative Ranks	0	0.00	0.00
Positive Ranks	17	9.00	153.00
Ties	0	–	–

Table 4 shows no negative ranks (N = 0); all 17 students obtained positive ranks (mean rank = 9.00), indicating that every participant's posttest score increased over the pretest, with no ties.

Table 5. Wilcoxon Signed Ranks Test Statistics

Statistic	Value
Z	-3.684
Asymp. Sig. (2-tailed)	< 0.001
Effect size, $r = Z/\sqrt{N}$ (N = 17)	0.89 (large)

The Wilcoxon Signed-Rank Test yielded $Z = -3.684$, $p < .001$, so H_0 is rejected: there is a statistically significant improvement in students' chemistry literacy scores from pretest to posttest. The corresponding effect size, $r = Z/\sqrt{N} = 3.684/\sqrt{17} = 0.89$, indicates a large effect by conventional benchmarks. Because no negative ranks occurred, no student showed a decline, suggesting that the learning activities were associated with gains for participants across the range of initial ability levels. As previously noted, in the absence of a control group this pattern should be read as a strong within-group association rather than definitive proof that the worksheet alone caused the improvement.

To quantify the magnitude of improvement, N-gain analysis was conducted. Descriptive statistics of pretest and posttest scores are presented in Table 6.

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Table 6. Descriptive Statistics of Pretest and Posttest Scores

Variable	Mean	SD	Min	Max
Pretest	73.53	8.62	60	90
Posttest	97.06	4.70	90	100
Gain	23.53	7.86	10	40

The mean score increased from 73.53 (SD = 8.62) at pretest to 97.06 (SD = 4.70) at posttest, an average gain of 23.53 points. The comparatively larger pretest SD suggests heterogeneous prior knowledge among students entering the intervention, while the reduced posttest SD indicates a more homogeneous distribution of outcomes afterward. This narrowing may reflect scaffolded learning equalization, in which lower-achieving students catch up with peers through the structured six-stage cycle; it may also, at least partly, reflect a ceiling effect, since posttest scores clustered near the maximum attainable score. Both interpretations are plausible and cannot be fully disentangled without a control group or a more difficult/discriminating instrument, and we present them here as competing explanations rather than a settled conclusion.

N-gain values for each chemistry-literacy dimension are presented in Table 7.

Table 7. N-Gain Score per Chemistry Literacy Aspect

Chemistry Literacy Aspect	Average N- Gain	SD	Category
Content Aspect	0.93	0.11	High
Context Aspect	0.83	0.14	High
Process Aspect	1.00	0.00	High
Attitude Aspect	0.67	0.18	Medium
Overall Average	**0.86**	**0.11**	**High**

The overall high N-gain (0.86), together with the significant Wilcoxon result ($Z = -3.684$, $p < .001$, $r = 0.89$), indicates a substantial improvement in chemistry literacy associated with the intervention, plausibly reflecting the contribution of contextual, inquiry-based learning to conceptual understanding, scientific reasoning, and problem-solving.

The process aspect showed a perfect N-gain (1.00; SD = 0.00), indicating uniform mastery of scientific-inquiry skills across all students. While this may reflect effective procedural scaffolding within PjBL consiste nt with a constructivist, learning-by-doing account in which repeated hands-on engagement (extraction, formulation, and product evaluation) builds consistent procedural knowledge a perfect score with zero variance

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also warrants critical scrutiny. Because the 10-item instrument distributed items across four dimensions, the process aspect was likely represented by relatively few items; a small item count, items that were too easy, or a broad/lenient scoring rubric could all produce an artificial ceiling independent of true mastery. We are unable to distinguish between these explanations with the current data, and we recommend that future instrument development increase the number of process-aspect items, evaluate item difficulty and discrimination indices, and pilot the instrument on a comparable sample before use.

The content aspect also showed a high N-gain (0.93; SD = 0.11), suggesting improved conceptual understanding of colloid systems and the bioactive compounds in pineapple peel. This is consistent with experiential-learning accounts in which conceptual knowledge is strengthened through active engagement with real-world applications (Mellyzar et al., 2022), and with reports that STEM-PjBL interventions can reinforce both conceptual understanding and broader scientific-literacy dimensions (Dibyantini et al., 2023).

The context aspect (N-gain = 0.83; SD = 0.14) reflects students' improved ability to connect chemical concepts with everyday and environmental situations. Using pineapple peel waste as the learning context plausibly supported environmental awareness and sustainable thinking, consistent with contextual and waste-valorization approaches to chemistry instruction (Martín-Alfonso & Yáñez, 2024; Alia, 2024).

By contrast, the attitude aspect showed the lowest N-gain (0.67; medium category), although the scientific attitude questionnaire indicated a strongly positive response overall (M = 4.78/5.00). This discrepancy suggests that while cognitive and procedural gains can occur relatively quickly through structured intervention, affective dimensions such as scientific attitude may require longer-term reinforcement shaped by classroom culture, prior experience, and sustained environmental support beyond a two-meeting intervention.

Taken together, these results suggest that different literacy dimensions respond differently to a short-term project-based intervention: procedural skills improved most through direct experimentation, conceptual understanding improved through integration with hands-on practice, while attitudinal change appeared comparatively slower. This pattern is broadly consistent with prior project-based learning research in chemistry education (Pratiwi & Ikhsan, 2024; Lethulur et al., 2025), and supports the relevance of contextual, waste-based instructional approaches for

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chemistry education in madrasah settings while underscoring, again, that the present pre-experimental design limits how strongly these associations can be interpreted as causal.

This study is limited by its one-group pre-experimental design without a control group, its small sample size (n = 17, one intact class), and a short two-meeting intervention duration; inter-rater reliability of observation data could also not be computed because observers rated different groups rather than the same group. Future research should incorporate control or comparison groups, larger and more diverse samples, longer intervention periods, and overlapping observation protocols to better capture long-term effects particularly on attitudinal development and could explore integration with digital learning tools, STEM-based instruction, or ethnoscience approaches.

CONCLUSION

This study analyzed the improvement of Grade XI students' chemistry literacy at MA Al Jawami associated with the implementation of a project-based worksheet on body lotion production from pineapple peel extract. A statistically significant pretest posttest improvement was found (Wilcoxon $Z = -3.684$, $p < .001$; effect size $r = 0.89$), with an overall high N-gain of 0.86. Gains occurred across all four chemistry-literacy dimensions content (0.93), context (0.83), process (1.00), and attitude (0.67) with the largest gain in the process dimension and the smallest, though still meaningful, gain in the attitude dimension.

These findings suggest that the six-stage project-based worksheet, contextualized through pineapple peel waste utilization, is associated with stronger scientific inquiry skills, conceptual understanding, and contextual/environmental awareness among students. However, because the study used a one group pre-experimental design without a control group and a small, single-class sample, these findings represent preliminary, classroom-level evidence rather than a generalizable causal claim. Future research using quasi-experimental or randomized controlled designs with larger and more varied samples is recommended to confirm and extend these results.

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REFERENCES

Aisyah, S., & Wiyarsi, A. (2025). Development of a culturally contextualized chemistry literacy test based on West Kalimantan culture on thermochemistry topics. *Jurnal Pendidikan Matematika dan Sains, 13*(2), 232–241. https://doi.org/10.21831/jpms.v13i2.84709

Alia, R. (2024). Analisis penerapan pendekatan etnosains dalam pembelajaran kimia untuk meningkatkan literasi sains pada siswa. *JRPK – Jurnal Riset Pendidikan Kimia, 14*(2), 144–149. https://doi.org/10.21009/jrpk.142.09

Almulla, M. A. (2020). The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. *SAGE Open, 10*(3). https://doi.org/10.1177/2158244020938702

Amdayani, S., Dibyantini, R. E., Syafriani, D., & Dalimunthe, M. (2025). Development of STEM-PjBL-based teaching materials to enhance students' science literacy on acid-base topic. *Jurnal Pendidikan MIPA, 26*(3), 1289–1307. https://doi.org/10.23960/jpmipa.v26i3.pp1289-1307

Bilad, M. R., Zubaidah, S., & Prayogi, S. (2024). Addressing the PISA 2022 results: A call for reinvigorating Indonesia's education system. *International Journal of Essential Competencies in Education, 3*(1), 1–12. https://doi.org/10.36312/ijece.v3i1.1935

Cigdemoglu, C., & Geban, O. (2015). Improving Students' Chemical Literacy Levels On Thermochemical And Thermodynamics Concepts Through A Context-Based Approach. *Chemistry Education Research And Practice*, *16*(2), 302–317. Https://Doi.Org/10.1039/C5rp00007f

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Delima, D., Windayani, N., Aisyah, R., Sunarya, R. R., & Sukmawardani, Y. (2025). Application of project-based worksheet to develop students' scientific performance through making hand cream from black rice kefir. *Jurnal Pendidikan MIPA, 15*(2). https://doi.org/10.37630/jpm.v15i2.2803

Dibyantini, R. E., Amdayani, S., Siregar, M. I., & Syafriani, D. (2023). Application of STEM-PjBL based chemistry module to improve science literacy and student learning motivation. *Jurnal Penelitian Pendidikan IPA, 9*(Special Issue), 95–102. https://doi.org/10.29303/jppipa.v9ispecialissue.5872

Hake, R. R. (1999). Analyzing change/gain scores. http://lists.asu.edu/cgi-bin/wa?A2=ind9903&L=aera-d&P=R6855

Hernández-Montesinos, I. Y., Carreón-Delgado, D. F., Lazo-Zamalloa, O., Tapia-López, L., Rosas-Morales, M., Ochoa-Velasco, C. E., Hernández-Carranza, P., Cruz-Narváez, Y., & Ramírez-López, C. (2024). Exploring agro-industrial by-products: Phenolic content, antioxidant capacity, and phytochemical profiling. *Antioxidants, 13*(8). https://doi.org/10.3390/antiox13080925

Juandi, D., Lethulur, N. D., & Dahlan, J. A. (2024). The effectiveness of discovery, inquiry, problem, and project-based learning in mathematics education: A systematic literature review. *Jurnal Pendidikan MIPA, 26*(1), 268–279. https://doi.org/10.23960/jpmipa/v26i1.pp268-279

Manik, A., Sidauruk, S., & Meiliawati, R. (2024). Analysis of science literacy and chemical literacy content on green chemistry materials in chemistry textbooks class X high school in Palangka Raya City. *Chemined, 13*(1). https://journal.unnes.ac.id/journals/chemined

Martín-Alfonso, J. E., & Yáñez, R. (2024). Integration of teaching laboratory activities based on the valorization of industrial waste into chemical education to address the emerging sustainable development goals. *Journal of Chemical Education, 101*(10), 4405–4410. https://doi.org/10.1021/acs.jchemed.4c00729

p-ISSN : 2503-4480
e-ISSN : 2721-2963
Vol. 11, No.1, April 2026
DOI: https://doi.org/ 10.36709/jpkim.v11i1.230

Mellyzar, M., Lukman, I. R., Alvina, S., Pasaribu, A. I., & Fadli, M. R. (2022). Chemical literacy of high school students: Analysis of cognitive abilities on colloid material. *Jurnal Penelitian Pendidikan IPA, 8*(6), 3128–3133. https://doi.org/10.29303/jppipa.v8i6.2377

Mubarok, A. S., Nurazizah, Z., Herawan, E., & Putri, D. P. (2025). Deep learning with project-based learning model for student creativity. *Pedagogia: Jurnal Pendidikan, 14*(2), 239–252. https://doi.org/10.21070/pedagogia.v14i2.1957

Pane, E. P., Lubis, N. F., & Simarmata, G. (2024). Application of interactive virtual lab media based on a STEM approach in improving students' scientific literacy. *Jurnal Penelitian Pendidikan IPA, 10*(12), 10736–10744. https://doi.org/10.29303/jppipa.v10i12.8589

Paz-Arteaga, S. L., Cadena-Chamorro, E., Goméz-García, R., Serna-Cock, L., Aguilar, C. N., & Torres-León, C. (2024). Unraveling the valorization potential of pineapple waste toward circular bioeconomy. *Sustainability, 16*(16). https://doi.org/10.3390/su16167236

Pratiwi, E. A., & Ikhsan, J. (2024). Project-based learning in chemistry education: A systematic literature review. *Jurnal Penelitian Pendidikan IPA, 10*(6), 343–354. https://doi.org/10.29303/jppipa.v10i6.7017

Rahmawati, Y., Erdawati, E., Ridwan, A., Veronica, N., & Hadiana, D. (2024). Developing students' chemical literacy through STEAM project on petroleum topic. *Journal of Technology and Science Education, 14*(2), 376–392. https://doi.org/10.3926/jotse.2221

Rahmi, C., Maisarah, M., & Sabarni, S. (2024). The effectiveness of scientific literacy-based worksheets. *Journal of Educational Chemistry, 6*(1), 49–56. https://doi.org/10.21580/jec.2024.6.1.20028

Salsabilla Khoirunnisa, K., Rahmawati Sunarya, R., & Sukmawardani, Y. (2025). The implementation of project-based worksheets to develop students' scientific performance through edible film production. *Katalis*, 8(1). https://ejurnalunsam.id/index.php/katalis

p-ISSN : 2503-4480
e-ISSN : 2721-2963
Vol. 11, No.1, April 2026 *DOI: https://doi.org/ 10.36709/jpkim.v11i1.230*

Sari, S. A., Dewi, R. S., Saputra, K., Kembaren, A., Hasibuan, H., & Talib, C. A. (2025). Integration of analytical chemistry flipbooks based on project-based learning in improving critical thinking skills and scientific literacy. *Jurnal Pendidikan IPA Indonesia, 14*(1), 59–69. https://doi.org/10.15294/jpii.v14i1.21038

Shwartz, Y., Ben-Zvi, R., & Hofstein, A. (2006). Chemical literacy: What does this mean to scientists and school teachers? *Journal of Chemical Education*.

Sjöström, J., Yavuzkaya, M., Guerrero, G., & Eilks, I. (2024). Critical chemical literacy as a main goal of chemistry education. *Journal of Chemical Education, 101*(10), 4189–4195. https://doi.org/10.1021/acs.jchemed.4c00452

Sugiyono. (2023). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta.

Sulastri, T., & Fatimah, S. (2024). The influence of STEAM-PjBL on students' colloid learning outcomes. *UNESA Journal of Chemical Education, 13*(2), 139–147.

Susanti, S., Husain, H., & Herawati, N. (2024). Pengembangan E-LKPD berbasis STEAM-project untuk meningkatkan literasi kimia peserta didik. *Chemistry Education Review, 8*(1), 2597. https://doi.org/10.26858/cer.v4i1.13315

Wardani, S. F., Yamtinah, S., Mulyani, B., Susilowati, E., Ulfa, M., Masykuri, M., & Shidiq, A. S. (2024). Differentiated learning: Analysis of students' chemical literacy on chemical bonding material through culturally responsive teaching approach integrated with ethnochemistry. *Jurnal Penelitian Pendidikan IPA, 10*(4), 1747–1759. https://doi.org/10.29303/jppipa.v10i4.6167

Yasinta, R., Haryani, S., Sumarti, S., Harjono, D., Kimia, J., Matematika, F., Ilmu, D., & Alam, P. (2023). Analysis of metacognition in PjBL worksheets on electrolyte and non-electrolyte materials. *JIPK, 17*(1). http://journal.unnes.ac.id/nju/index.php/JIPK