JSEP (Journal of Sciences Education and Practice)
Published by Universitas Pakuan
https://jsep-pasca.unpak.ac.id/index.php/jsep
Vol. 10, No. 1, 2026 | Pages 71-85
ISSN: E 2549-7170 / P 2548-950X

Analysis of Students' Chemistry Literacy Improvement in Acid-Base Material Through Ethnoscience-Based Learning Using Natural Indicator Paper from Dayak Onion (*Eleutherine palmifolia* (L.) *Merr.*)

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Article Info	Abstract
Keywords: *acid – base; chemical literacy; dayak onion; ethnoscience* **Received:** 18/02/2026 **Revised:** 15/03/2026 **Accepted:** 12/05/2026	This study aims to develop natural indicator paper based on Dayak onion (*Eleutherine palmifolia* (L.) *Merr.*) extract and assess its effectiveness in improving high school students' chemical literacy through ethnoscience-based learning. The study was conducted in two stages: the creation of indicator paper and its implementation in acid-base learning using a one-group pretest-posttest design. The research subjects were 32 students. Data were collected through tests, observations, and interviews, then analyzed using descriptive and inferential statistics. The results of the normality test showed that the data were normally distributed (Sig. pretest 0.379; posttest 0.892). The paired sample t-test showed a significant difference (Sig. 0.000 < 0.05). The increase in chemical literacy was indicated by an average N-Gain value of 0.798 (high category). These findings indicate that contextual learning based on local wisdom is effective in improving chemical literacy and supporting students' 21st-century skills.

INTRODUCTION

The educational curriculum is dynamic in line with the times (Briddick et al, 2018; Alfauzan & Tarchouna, 2017; Sava et al 2022). The development of the 21st century demands a curriculum that is able to facilitate students to have 21st-century skills such as science, literacy, numeracy, and responsiveness to technological developments (Maphosa & Mashau, (2014); Quieng et al. (2015); Miranda et al. (2021)). The development of the times also influences the restructuring of the workforce, creating changes in the job market, as well as demands for the complexity of human resource capabilities (Oanh & Dang, 2025). The magnitude of the demands that must be prepared is commensurate with the challenges that must be faced, such as the educational curriculum being able to provide opportunities for students to explore independently, encourage collaboration, support creativity, and improve critical thinking (Avdiu et al., 2024). Therefore, the educational curriculum must be developed to follow the demands of the times so that educational institutions are able to provide superior human resources and answer the challenges of the times.

The demand for 4C skills (critical, creative, communication, and collaboration) is one of the indicators that must be developed in educational institutions, such as the implementation of learning models and approaches that focus on improving student competencies (Salybekova et al., 2023). These 4C skills will be difficult to apply in the learning environment if students have experienced initial obstacles such as learning difficulties and decreased learning motivation (Harianto et al., 2026). These obstacles can be overcome by increasing student participation in the learning process (Avdiu et al., 2024) by improving the quality of learning such as contextual learning (Chen et al., 2021; Firmansah, 2022; Dewi et al., 2021; Hyun et al., 2020; Krasnova & Shurygin, 2020; Yani et al., 2021); Project-based learning (Tian et al., 2023; Santyasa et al., 2021; Masbukhin, et al., 2023); Problem-based learning (Valdez & Bungihan, 2019; Ayyildiz & Tarhan, 2018; Argaw et al, 2016); Learning with a STEM approach (Ješková et al, 2022; Han et al, 2021; Hacioğlu & Gülhan, 2021); Ethno-STEM-based learning (Harianto et al., 2026).

Chemistry is a science subject that is considered difficult by many students. This is influenced by the complexity of the skills students must have when studying it, such as the ability to calculate, memorize, remember, analyze, evaluate, and implement theories in everyday life (Childs & Sheehan, 2009; Woldeamanuel et. al. 2014). This complexity will affect students' learning motivation, which ultimately makes chemistry learning outcomes difficult to achieve (El Yazidi, 2024). Learning motivation is correlated with student literacy, where students with good literacy tend to have good learning motivation (Safari, 2025). In the context of chemistry learning, students tend to have chemical literacy in the poor category (Harianto et al., 2025; Yulianti et al., 2019). This will result in a decrease in learning motivation, which has an impact on students' affective, cognitive, and psychomotor competencies (Nurjadid et al., 2025).

A recommended innovation in chemistry learning is learning based on green chemistry and local wisdom (Mashami, 2025). This learning offers contextual learning to facilitate the delivery and understanding of chemistry material (Amanda et al., 2023). The local wisdom approach packaged in Ethno-STEM-based learning has also been shown to improve students' chemical literacy (Harianto et al., 2026). Students with good chemical literacy will be able to think critically, creatively, communicate effectively, and collaborate effectively. If the competencies required in the 21st century are met through good student literacy, educational institutions will be able to prepare a generation ready to meet the challenges of the times.

A preliminary study conducted through observations and interviews with students and teachers in high schools concluded that chemistry learning is still student-centered, and the contextualization of the material taught is not demonstrated through demonstrations or practical work. Improving students' psychomotor competencies through practical work is conceptual and expensive, resulting in environmental pollution. Furthermore, students are not trained enough to develop good chemical literacy skills by working on literacy-based problems, such as contextual problems, reasoning problems, and problems that stimulate students' creativity while learning chemistry. This preliminary study found that immediate improvements are needed in the chemistry learning process in schools.

Mashami, R. A & Ahmadi, P. (2025) emphasized that contextualized learning materials based on local wisdom and based on green chemistry have the potential to foster students' scientific understanding and involvement. Central Kalimantan is a province that has a lot of local wisdom in terms of art, culture, processed food and beverages, and medicines. One of the traditional medicines known among the community is Dayak onion (*Eleutherine palmifolia* (L.) *Merr*.) because it contains active compounds such as polyphenols, steroids, tannins, monoterpenoids, sesquiterpenoids, flavonoids, alkaloids, quinones, and saponins, and pharmacologically has antidiabetic, anticancer, anti-inflammatory, and antimicrobial properties (Puspadewi et al., 2013; Kusriadi, 2026). The pharmacological properties of antioxidants and lactagogums owned by Dayak onions are due to the presence of anthocyanins (Ekawati, 2018). Anthocyanin is a pigment that acts as a color changer caused by changes in pH (Masqood et al., 2025).

The anthocyanin content of Dayak onion (*Eleutherine palmifolia* (L.) *Merr*.) indicates that its extract can be used as a natural indicator to test the acidity of a solution. In addition, research discussing the use of Dayak onion extract (*Eleutherine palmifolia* (L.) *Merr*.) as a natural indicator of acids and bases has never been conducted. Therefore, this study aims to produce natural indicator paper from Dayak onion extract (*Eleutherine palmifolia* (L.) *Merr*.) and its impact on improving the chemical literacy of high school students.

METHODS

This research consists of two sessions, namely the first session on making Dayak onion indicator paper and the second session on implementing Dayak onion indicator paper in learning about acids and bases.

Stages of making indicator paper from Dayak onions

The manufacture of indicator paper begins with the manufacture of extracts from Dayak onions (*Eleutherine palmifolia* (L.) *Merr*.). The manufacture of extracts from Dayak onions refers to research (Sirajuddin & Suryanto, 2024) which has been modified. Dayak onions obtained from the green Lab of SMPN 3 Katingan Kuala are then cleaned of impurities and then the Dayak onions are separated from the stems and stalks. Then heated at room temperature for 5-7 days or until dry. After the Dayak onions are dry, they are blended and sieved with a size of 80 mesh to obtain simplicia with a uniform size. Next, the simplicia is macerated by soaking it in 95% ethanol with a ratio of 1: 4 (w / v) and stirring 3 times a day, the maceration process lasts for 3 days. After the maceration process, filtration is carried out to obtain the filtrate from Dayak onions. Next, the filtrate was tested to see the color changes at each pH variation, namely from pH 1 to pH 14. Then the Dayak onion indicator paper was made by soaking Whattman filter paper in the Dayak onion filtrate for 2 days, then drying it and cutting it into pieces.

Implementation stage of Dayak onion indicator paper for students

This stage uses a one-group pretest-posttest design with 27 students (11 males and 16 females). The pretest was conducted to determine students' initial chemical literacy, while the posttest was conducted to determine students' chemical literacy after ethnoscience-based learning using Dayak onion indicator paper. Data collection techniques were carried out through interviews, observations, and the implementation of tests and non-tests on students. Data analysis techniques were carried out using descriptive statistics and inferential statistics. The increase in chemical literacy was known by calculating the N-Gain or the difference between the pre-test scores (before ethnoscience-based learning using Dayak onion indicator paper) and post-test (after ethnoscience-based learning using Dayak onion indicator paper). The results of the pre-test and post-test were then tested for normality using the Saphiro Wilk normality test. If the significance value or probability value is <0.05, the data is not normally distributed. Meanwhile, if the significance value or probability value is >0.05, the data is normally distributed. Next, a paired sample t-test was conducted. If the Sig. value is <0.05, the data is normally distributed. (2-tailed) < 0.05, it can be concluded that there is an average difference between the pre-test and post-test results of chemical literacy. So it can be concluded that there is an effect of ethnoscience-based learning using Dayak onion indicator paper in improving students' chemical literacy. Preferably, if the Sig. (2-tailed) value is > 0.05, it can be concluded that there is no average difference between the pre-test and post-test results of chemical literacy. So it can be concluded that there is no effect of ethnoscience-based learning using Dayak onion indicator paper. Improvements in chemical literacy can be determined through N-Gain score analysis, which is the average pre-test and post-test results. This analysis can be used as a guide to determine the effectiveness of the developed teaching materials. The formula for determining the N-Gain score is as follows:

$$< g > = (\frac{(skor\ posttest)-(skor\ pretest)}{(skor\ maksimum)-(skor\ pretest)} \quad (1)$$

The N-Gain values obtained are then categorized based on the guidelines in table 1.

Table 1. N-Gain Value Categories

N-Gain Value	Categories
<g> ≥ 0,7	High
0,3 ≤ <g> ≤ 0,7	Medium
<g> < 0,3	Low

(Arikunto, 2009)

RESULT AND DISCUSSION

Making Dayak Onion Indicator Paper *(Eleutherine palmifolia (L.) Merr.)*

The process of making Dayak Onion indicator paper begins with the preparation of Dayak Onion extract. Maceration is the process of obtaining an extract from Dayak Onion powder soaked in 95% ethanol solvent for 3 days. Then, the filtrate is taken and a preliminary trial is carried out by implementing the filtrate in a solution that has been made from pH 1 - pH 14. The color produced from the Dayak Onion extract can be seen in Figure 1.

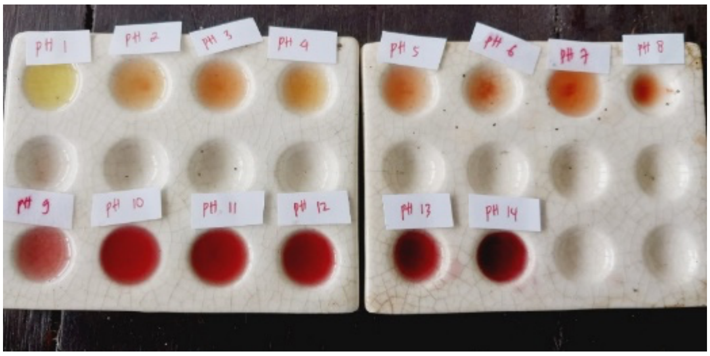

Figure 1. Color changes of pH 1 – pH 14 solution

Anthocyanin color is strongly influenced by the anthocyanin structure and the degree of acidity (pH) (Jackman, 1987). Anthocyanins tend to be colorless at neutral pH levels and pink to red at acidic levels (pH < 3). In alkaline levels (pH >10), they turn yellowish-green (Torskangerpoll, 2005). The solvent used influences the resulting color change (Fatihah & Zidny, 2023).

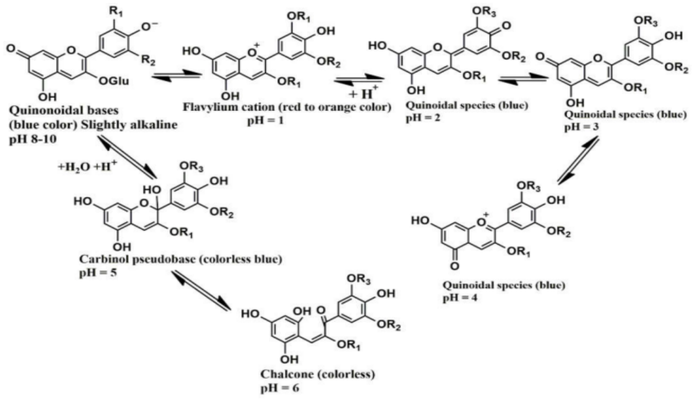

Figure 2. Structural transformation of anthocyanins due to pH changes (Miguel, 2011)

The color difference in Figure 1 is caused by changes in the pH of the solution, which also impacts changes in the anthocyanin structure. Anthocyanins are pigments derived from secondary metabolites of the flavonoid group and are polar compounds, so they can be extracted with polar solvents as well. Pratiwi & Priyani (2019) revealed that the use of ethanol solvents affects the total anthocyanin content, this is because ethanol and anthocyanin have relatively the same polarity compared to water. The changes in anthocyanin color caused by changes in the pH of the solution can be seen in Table 2.

Table 2. Anthocyanin color changes due to pH changes

pH	Color	pH	Color
1	Pale yellow	8	Dark orange-red
2	Light orange	9	Pinkish red
3	Brownish orange	10	Bright red
4	Yellow-orange	11	Deep red
5	Orange	12	Dark red
6	Reddish orange	13	Dark purplish red
7	Orange-red	14	Very dark red

Student Chemical Literacy

Ethnoscience-based learning using Dayak Onion indicator paper was tested for its impact on students' chemical literacy by evaluating pre- and post-test results. A prerequisite was a normality test using the Shapiro-Wilk normality test.

Table 3. Results of the Chemical Literacy Normality Test

	Kolmogorov-Smirnov		Shapiro-Wilk	
	df	Sig.	df	Sig.
Pre test	19	.200	19	.379
Post test	19	.200	19	.892

Table 3 shows that the Shapiro-Wilk normality test for the pre-test had a significance value of 0.379, while the post-test had a significance value of 0.892. Therefore, based on the significance values for the pre-test and post-test, it can be concluded that the data are normally distributed because their significance values are >0.05. The results of this normality test can be used as a reference for selecting parametric hypothesis testing items, namely the dependent t-test (Paired t-test). Based on the analysis, the significance value between students' pre-test and post-test scores was 0.000, or a sig. <0.05. This significance value concludes that there is a difference in the average scores between the pre-test and post-test results for chemical literacy, indicating the impact of implementing ethnoscience-based learning using Dayak onion indicator paper on students' chemical literacy. Further analysis of the increase in students' average chemical literacy scores before and after ethnoscience-based learning using Dayak onion indicator paper was conducted using the N-Gain test for each chemical literacy indicator. The results of the N-Gain analysis for each student chemical literacy indicator are shown in Table 4.

Table 4. Result of the N-Gain Analysis

Student	Indicator	Question Number	N-Gain	Category
27 Siswa	Content	1, 2, 3, 4	0,801	High
	Context	5	0,764	High
	Competence	6, 7	0,854	High
	Science Attitude	8, 9, 10	0,773	High
Average			0,798	High

Based on the data presented in Table 4, each chemical literacy indicator content, context, competency, and science attitude has an average N-Gain of "High." Furthermore, the average N-Gain for each indicator can be concluded that ethnoscience-based learning using Dayak onion indicator paper has a positive impact on students' chemical literacy. Meanwhile, a paired t-test hypothesis test showed a difference in students' average chemical literacy scores before and after ethnoscience-based learning using Dayak onion indicator paper. Student interviews revealed that the chemistry content presented was based on local wisdom about traditional medicine from Dayak onions, thus facilitating students' imagination of abstract concepts. This is because the problems or material presented are contextual. Culture-based learning or local wisdom can hone students' scientific explanation skills (Heliawati et al., 2022).

Students' efforts to interpret and understand chemistry holistically (both its concepts and implications for everyday life) are part of chemical literacy. If students have good chemical literacy, they will be able to meet the demands of 21st-century thinking skills, namely critical thinking, creativity, collaboration, and good communication (Wiyarsih et al., 2021). Chemical literacy, according to Shwartz et al. (2005), involves several components, such as: Understanding chemical properties, norms, and methods. This means how chemists work and how the resulting products are accepted as scientific knowledge; Understanding chemical theories, concepts, and models. The subject lies in theories that have broad applications; Understanding how chemistry and chemistry-based technology relate to each other. Chemistry seeks to produce explanations of nature, while chemical technology seeks to change the world itself. The concepts and models produced by both fields are strongly related, so that each influences the other. Appreciating the impact of chemistry and chemical technology on society.

CONCLUSION

Ethnoscience-based learning using natural indicator paper from Dayak onion extract (*Eleutherine palmifolia* (L.) *Merr*.) has been proven effective in improving students' chemical literacy. This is supported by the results of the paired sample t-test which showed a significance value of 0.000 (<0.05), so there is a significant difference between the pretest and posttest results. The data also show that the results of the *Shapiro-Wilk* normality test in the pretest were 0.379 and the posttest were 0.892 (both >0.05), which means the data are normally distributed and worthy of parametric testing. In addition, the increase in students' chemical literacy is strengthened by an average N-Gain value of 0.798 (high category). These findings are also supported by interview results, which indicate that local wisdom-based learning makes the material more contextual and easier for students to understand. Therefore, the use of Dayak onion indicator paper is not only effective as an environmentally friendly and economical learning media innovation, but also improves conceptual understanding, learning engagement, and supports the development of 21st-century skills such as critical thinking, creativity, communication, and collaboration.

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