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The Effectiveness of the Integrated Ethno-STEM Problem-Based Learning (PBL) Model to Improve Students' Chemistry Literacy

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Abstract

This study aims to analyze the effectiveness of integrated ethno-STEM PBL worksheets in improving students' chemistry literacy skills. The study used a one-group pretest-posttest design. The population consisted of all students in the 2025/2026 academic year. The sample consisted of 80 students. The instrument used in the study was an essay test that had validity, discriminating power, difficulty level, and reliability with good question criteria. The effectiveness of the integrated ethno-STEM PBL worksheets was determined through a classical mastery test and a chemistry literacy N-gain test. Based on the results of the classical mastery test and N-gain test for each indicator of chemical literacy, the PBL ethno-STEM worksheets were declared effective in improving chemical literacy if the classical mastery test was > 80% and the N-gain value for each indicator of chemical literacy was at least 0.70, which is in the high category. The results showed that classical mastery reached 92.50%, the overall N-gain test for the knowledge aspect was 82.43%, the context aspect was 83.53%, and the competency aspect was 73.78%. Referring to the established achievement indicators, the PBL etno-STEM LKPD on chemical reaction equations is effective in improving students' chemistry literacy in the high category.

Keywords: Effectiveness, LKPD, PBL, Ethno-STEM, Chemical Literacy

Introduction

Education is an effort to prepare students to play a role in various future environments through guidance and training [1]. One of the prerequisites for realizing 21st-century education is literacy skills. According Atmazaki [2], the basic literacies that must be mastered are reading and writing literacy, numeracy literacy, digital literacy, financial literacy, cultural and civic literacy, and science literacy. Science literacy consists of physics literacy, biology literacy, and chemistry literacy. This study will focus on one of the important fields of science in life, namely chemistry. To develop knowledge of chemistry, it is necessary to improve chemistry literacy. According to Shwartz [3], people who have chemistry literacy must understand the basic concepts of science/chemistry.

The chemical literacy of students in Indonesia is still at an average level. Research Mutmainah [4] states that students' chemical literacy skills are in the moderate category. This is influenced by several factors, namely a lack of reading habits, a learning process that is not fully related to the context of everyday life, and evaluation questions that do not develop students' chemical literacy skills.

Low chemical literacy results in students' lack of ability to develop and improve their creative skills in applying science in daily life, difficulty in problem solving, and slow decision making [5]. Learning is more dominant with non-contextual content, which burdens students [6]. Contextual chemistry learning is related to aspects of life, so that students can connect the phenomena around them with chemical concepts.

Efforts that can be used to improve chemistry literacy include the use of local culture in science education, as this not only clarifies concepts but also encourages the preservation of local wisdom through education [7]. Research Asmayawati [8] shows that integrating local wisdom into learning can strengthen the effectiveness of teaching methods and curricula in improving students' chemistry literacy. In line with the research Masayu [9] Suwandi [10], the ethnoscience approach can significantly improve students' chemistry literacy skills.

Ethnoscience-based chemistry learning can be used in chemistry learning to develop students' science literacy skills [11]. The learning process that uses a local knowledge approach is highly dependent on the contribution of teachers as instructors in the

classroom to be able to integrate local knowledge into learning materials. This form of integration has not yet been fully implemented in the learning process in the classroom, so that its great potential should be utilized to help students understand the learning material more easily [12].

Incorporating local wisdom into school subjects is an effective way to introduce local wisdom to students. The teaching materials used to deliver learning content can facilitate this integration. There are various types of teaching materials used in learning, one of which is the Student Worksheet (LKPD) [13-15]. The use of LKPD guides students to gain direct learning experiences, making them more active in the learning process compared to the use of other teaching materials [16].

Ethno-STEM-based LKPD is a new innovation in the chemistry learning process [17]. Ethno-STEM-based LKPD is superior because it integrates local wisdom with the STEM approach to create contextual and relevant learning. Integrated STEM education allows teachers to deliver science, technology, engineering, and mathematics content and connect it to real-life situations [18]. This approach encourages students to understand scientific concepts through local culture, such as the tradition of eating betel nut, the process of making sago, *papeda*, and smoking fish (*ikan asar*). In line with the research Sumarni [19], bringing this local knowledge into STEM education will provide meaningful and beneficial learning experiences for students.

Thus, integrating local wisdom into chemistry learning can foster students' science literacy [20]. This research is also in line with Elennita [21] showing that integrated STEM learning based on local wisdom is effective in improving students' science literacy.

LKPD can be designed following the stages of one of the existing learning models, namely Problem Based Learning (PBL). The PBL model emphasizes active student involvement in solving contextual problems, thereby encouraging students to build knowledge independently and meaningfully. The application of Problem-Based Learning (PBL) has been proven to improve students' chemistry literacy skills [22], because this model provides space for students to be active in the learning process through problem solving [23]. Additionally, learning using the PBL model based on ethnoscience is also effective in improving students' chemistry literacy, as it connects chemistry concepts with cultural contexts and local wisdom that are close to students' lives [24]. With this PBL model, students can construct knowledge by building reasoning, which is expected to increase learning motivation by solving problems and various alternative solutions as well as identifying existing problems [25].

Many chemistry materials can be integrated with local wisdom to facilitate student learning. One of them is the material on chemical reaction equations. The material on chemical reaction equations is often considered difficult because it is introductory material and a prerequisite for subsequent material. Furthermore, chemical reaction equation material generally only measures knowledge (cognitive) and does not measure chemical literacy. Therefore, this study uses chemical reaction equation material to assess or measure chemical literacy.

In previous research, an integrated ethno-STEM PBL LKPD model was developed, namely the tradition of eating betel nut, the process of processing sago, *papeda*, and smoking fish (*ikan asar*) in chemical reaction equation material, which was validated by experts and received a very good response from students. However, the effectiveness of the developed LKPD in improving students' chemical literacy has not been tested. Therefore, the purpose of this study is to apply the integrated ethno-STEM PBL LKPD in teaching chemical reaction equations, followed by analyzing its effectiveness in improving students' chemical literacy skills.

Materials and Methods

This research was conducted at SMA Negeri 3 Kota Sorong in the 2025-2026 academic year with a population of 8 classes. The sample in this study consisted of 2 classes with a total of 80 students, comprising 44 male students and 36 female students. The sample in this study was selected using purposive sampling based on the teacher's consideration because the class was taught by one teacher. The research method used was experimental research with a one-group pretest-posttest design.

Table 1: One-group pretest-posttest research design

Pretest	*Treatment*	*Posttest*
O_1	X	O_2

Based on Table 1, where X = treatment with LKPD learning using an integrated PBL etno-STEM model, O_1= initial test; O_2= final test. A written test consisting of eight essay questions was used as part of the data collection method, which had been tested for validity, reliability, discriminating power, and level of difficulty of the questions based on good question criteria. The three aspects of chemical literacy were knowledge, context, and competence. Classical mastery testing and N-gain were used to analyze the data for each aspect of students' chemical literacy. The standard for the effectiveness of the classical mastery test is that students must at least meet the effective level with a criterion of > 80% of all objects. Further analysis of the content, context, and competency aspects of chemical literacy is proven by the N-gain test if each chemical literacy Indicators at least 0,70 in the high category.

Result and Discussion

This study aims to determine the effectiveness of using the PBL-integrated etno-STEM LKPD model on chemical reaction equation material to improve students' chemical literacy. Students' initial abilities and chemical literacy results were determined through a test with 8 essay questions. The tests were administered before and after the learning process. The average pretest score for 80 respondents was 23.68, while the posttest score was 84.83. The results of the classical mastery test obtained by students with a minimum passing grade of 75 can be seen in Table 2.

Table 2: Percentage of Learning Outcomes

Description	Number	percentage
Proficient	74	92,50%
Not completed	6	75%

Based on Table 2.6 out of 80 students have not achieved the minimum competency standard.

To measure the extent of improvement in chemistry literacy skills, an N-gain test was conducted. The N-gain score was measured using the following formula:

$$\text{n-gain}=\frac{Spost-Spre}{Smax-Spre}$$

Based on the results of the N-gain test analysis, 8 respondents had moderate criteria with an average pretest score of 25.25 and a posttest score of 71.75, while 72 respondents had high criteria with an average pretest score of 23.50 and a posttest score of 86.28. Overall, an N-gain score of 0.80 was obtained, which is categorized as high. The moderate and high N-Gain results are presented in a pie chart as shown in Fig 1.

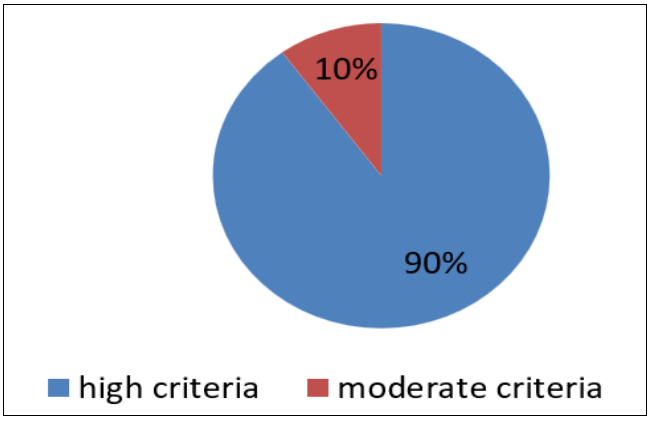

Fig 1: Overall N-Gain Pie Chart

Fig 1 shows the percentage of N-Gain criteria obtained, namely 90% high N-Gain criteria and 10% moderate criteria. These results indicate that the application of integrated ethno-STEM PBL LKPD was able to significantly improve students' chemistry literacy from the pretest to the posttest. The high N-gain category shows that the applied learning t not only had an impact on improving concept mastery, but also on students' ability to relate chemistry concepts to everyday contexts and apply them in problem solving. The results of this study are in line with the research Masayu [9] which states that chemistry learning with an ethnoscience approach can improve students' chemistry literacy with N-gain values in the moderate to high categories. It can be concluded that the use of the PBL model LKPD integrated with ethno-STEM in chemical reaction equation material provides excellent results in improving the chemistry literacy of grade X students at SMA Negeri 3 Kota Sorong.

Furthermore, an N-gain test based on male and female students is presented in Fig 2.

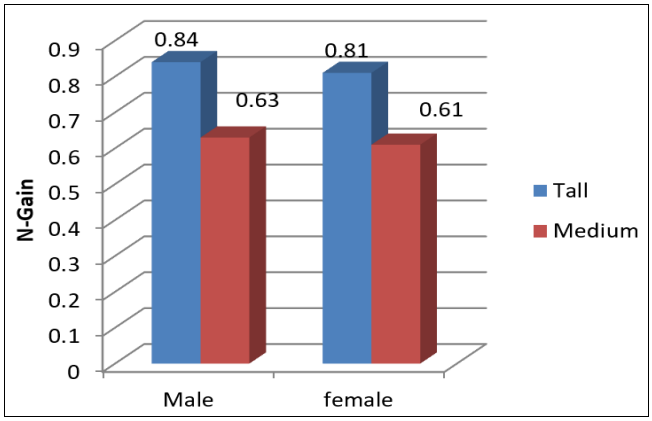

Fig 2: N-Gain result for male and female students

Based on Fig 2, the results of the chemistry literacy N-gain test show that both male and female students experienced an increase in chemistry literacy in the high category. There were 6 male students in the moderate category and 2 female students with overall N-gain scores of 0.63 and 0.61, respectively. Meanwhile, 38 male students obtained a high N-gain criterion with a total overall N-gain of 0.84, and 34 female students obtained a high N-gain score with a total N-gain of 0.81.

The N-gain scores between male and female students showed a relatively small difference, so it can be concluded that the improvement in students' chemistry literacy was not significantly influenced by gender. This is in line with the research findings [26-28], which state that there is no significant difference between male and female students in terms of chemistry literacy levels, and both are in the very good category. Thus, the integrated ethno-STEM PBL LKPD is effective in improving students' chemistry literacy comprehensively and equally, with no difference in improvement between male and female students.

An N-gain test was also conducted on each chemistry literacy indicator. The results obtained are presented in Fig 3.

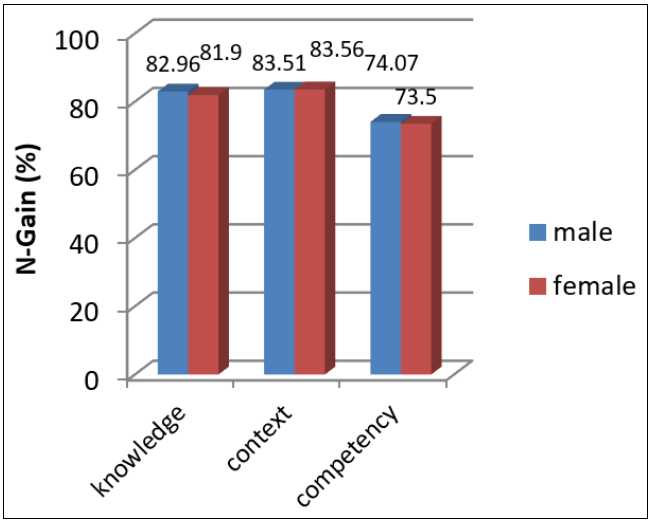

Fig 3: Average N-gain Scores for Chemical Literacy

The achievement of the three chemistry literacy indicators, namely knowledge, context, and competence, shows that all indicators have met the specified standard, namely an N-gain value ≥ 0.70 in the high category. The achievement of these three indicators is in the high category for both male and female students, indicating that the increase in chemistry literacy occurred equally in both male and female students.

However, there are differences in achievement between indicators for male and female students. The context indicator shows the highest percentage of achievement, followed by the knowledge indicator, while the competency indicator has a relatively lower achievement compared to the others.

The knowledge aspect was analyzed from students' answers to chemistry literacy questions after learning using the integrated PBL etno-STEM model worksheet. There were two knowledge aspect indicators related to chemical reaction equations. These indicators were about the characteristics of chemical reactions and the reactants and

products of reactions. The results of the analysis of students' chemical literacy abilities were reviewed from the knowledge aspect related to chemical reaction equations, which produced an average percentage of 82.96% for male students and 81.9% for female students in the high category. These results showed that there was no significant difference between the chemical literacy levels of male and female students.

The knowledge indicator achieved a high percentage of achievement in male and female students. This shows that students are able to understand the chemical concepts learned through the applied learning. The high achievement in this indicator indicates that learning using the PBL-integrated ethno-STEM LKPD model is effective in helping students build a strong conceptual understanding without any significant differences in ability between male and female students.

These results are in line with the research Mutmainah [29] which states that chemistry learning with the PBL model can significantly improve students' conceptual mastery.

The context indicator showed the highest achievement percentage compared to other indicators, both for male and female students. This indicates that the ability to relate chemistry concepts to everyday phenomena is at the same level for male and female students. This equality in achievement indicates that the integration of the ethno-STEM context in PBL learning provides the same learning experience for male and female students.

The high achievement on the context indicator shows that students have been able to relate chemistry concepts to contextual phenomena in everyday life through integrated ethno-STEM PBL learning, which emphasizes real and meaningful problems. In line with the research [30, 31] that learning that is relevant to everyday experiences helps students form more meaningful understanding, thereby encouraging students to apply their knowledge in solving everyday problems [32]. It also increases their learning motivation and understanding [33].

These high achievements reinforce that the learning that has been implemented is relevant to the students' learning experiences. In this indicator, students are asked to explain the color change in the mouth due to eating betel nut and to write down the chemical reaction equation related to the fish smoking process (*ikan asar*). Learning that links chemistry material to the local cultural context makes it easier for students to understand concepts contextually. Research by Vasthi & Hairida [34], states that students have been able to master chemistry concepts holistically and apply them in real contexts to solve problems they face. Thus, LKPD combined with local wisdom can influence the learning process of students [35].

The competency indicator received a lower percentage compared to the knowledge and context indicators, but it is still in the high category. This indicator shows that students have sufficient ability to explain phenomena scientifically, evaluate investigations, and interpret scientific data and evidence. This is in line with the research Mellyzar [36] states that these three indicators are important benchmarks in assessing students' overall science literacy achievements.

The average percentage of students in terms of competency was obtained with male students scoring 74.07% and female students scoring 73.50%, both in the high category. These results show that there is no significant difference between the chemistry literacy levels of male and female students.

This relatively small difference in achievement indicates that there is no significant difference between the chemistry literacy levels of male and female students in terms of competency. These results are in line with the research [37] which states that female students tend to have slightly higher chemistry literacy scores than male students, especially in conceptual understanding, but the difference is relatively small statistically.

The relatively lower achievement of the competency indicator can be understood because this indicator requires higher-order thinking skills that require continuous practice and habituation [38, 39]. In the competency aspect, PBL-based learning not only requires conceptual understanding but also the ability to apply these concepts in the scientific process and contextual problem solving.

The achievement of chemistry literacy at the highest competency level, namely in evaluating scientific investigations, required students to evaluate the arguments contained in the questions presented related to papeda. The results obtained showed that students were able to plan how to solve the problems. These results indicate that the ethno-science context related to papeda in this LKPD is good for facilitating students to better understand the material being taught. The scores obtained from the chemical literacy analysis based on the pretest and posttest values showed an increase in students' chemical literacy, indicating that the integrated ethno-STEM PBL LKPD used was effective. This is in line with the research Muhktar & Kurniawati [40] which states that ethnoscience-based PBL LKPD is effective when applied to students with a Ngain value of 79%.

Meanwhile, the lowest achievement in chemistry literacy was found in the indicator of explaining scientific phenomena. This is in line with the research [41] which shows that students' ability to explain scientific phenomena is in the low category, one of the contributing factors being their weak reading skills, resulting in incomplete understanding of the taught material.

The results of the study indicate that the use of PBL-based LKPD integrated with ethno-STEM is able to improve students' chemistry literacy in all indicators, namely knowledge, context, and competence. This study is in line with Susanti [42] which states that STEAM-based LKPD can improve students' chemistry literacy skills.

However, several limitations were found in its implementation, particularly in terms of chemistry literacy competency. The achievement of competency indicators was relatively lower than that of knowledge and context indicators, indicating that PBL-based LKPD integrated with ethno-STEM has not fully optimized students' ability to explain phenomena scientifically, evaluate investigations, and interpret scientific data and evidence, thus requiring improvement. This is in line with the research Mellyzar [36] which states that science literacy competency indicators tend to have lower achievements because they require higher-order thinking skills and complex scientific reasoning.

The limitations of this study were also influenced by the limited learning time, as students were approaching their final exams (UAS), so learning time was divided between completing the material, practicing questions, and preparing for exams. As a result, some students may not have fully mastered all indicators of chemistry literacy to the maximum extent, although overall, the integrated PBL LKPD etno-STEM still showed a significant improvement.

Conclusion

Based on the results of research and data analysis, it can be concluded that the application of the integrated ethno-STEM PBL model LKPD is able to improve students' chemistry literacy. This can be seen from the significant increase in pretest to posttest scores and overall N-gain scores in the high category. Most students achieved learning completeness and an increase in chemistry literacy occurred in all indicators (knowledge, context, and competence). This improvement occurred evenly among male and female students without significant differences. Although the competency indicator had a relatively lower achievement, in general, the integrated ethno-STEM PBL LKPD proved to be effective, even though there were still limitations in learning time that affected the optimization of achievement in several indicators.

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