



Analysis of the Implementation of the Integrated Ethnoscience Project-Based Learning (PjBL) Model in NTT Ikat Weaving Dyeing for High School Chemistry Learning

Visensia H. B. Hayon^{1*}, Theresia Wariani¹, Yanti Rosinda Tinenti¹, Alfons Bunga Naen¹, Hironimus Tangi¹, Florentina Yasinta Sepe¹, Ana Maria Derosari²

¹ Universitas Katolik Widya Mandira, Kupang, Indonesia.

² Universidade Nasional Timor Lorosa'e, Liceau Dili, Timor Leste.

Received: November 13, 2025

Revised: December 24, 2025

Accepted: January 25, 2026

Published: January 31, 2026

Corresponding Author:

Visensia H. B. Hayon

vincehayon@gmail.com

DOI: [10.29303/jppipa.v12i1.13874](https://doi.org/10.29303/jppipa.v12i1.13874)

 Open Access

© 2026 The Authors. This article is distributed under a (CC-BY License)



Abstract: This study aims to comprehensively analyze the implementation of the Project-Based Learning (PjBL) Model integrated with ethnoscience in NTT Ikat Weaving dyeing in Chemistry learning at high schools, including its impact, critical challenges, and strategies for strengthening the competencies of teachers and students. This study uses a qualitative method with a descriptive analytical approach. The research subjects consisted of Chemistry teachers as model implementers and 11th-grade students involved in the learning project. The main research instruments used included observation sheets on the implementation of PjBL focusing on teacher performance, teacher questionnaires, student questionnaires, in-depth interviews with teachers, and in-depth interviews with students. The results show that the implementation of this model was very good (above 82%) in terms of PjBL syntax and ethnoscience integration, providing a significant positive impact in the form of increased motivation, student involvement, and teacher self-efficacy, as well as an increase in the understanding of contextual chemistry concepts. However, the implementation faced critical challenges, particularly in terms of logistical constraints and rigid curriculum time allocation, as well as weaknesses in teacher assessment instruments and criteria (Column 3 criteria were rated the lowest, $\bar{x} = 3.27$). For sustainability, a strategy to strengthen teacher competencies is needed through research collaboration with local artisans and institutional support in providing logistics and adjusting curriculum time allocation. Overall, integrated PjBL ethnoscience has proven to be effective and transformative, but its optimization is highly dependent on strong systemic support.

Keywords: Chemistry education; Curriculum implementation; Ethnoscience; NTT Ikat Weaving; Project-Based Learning

Introduction

The context of 21st-century education demands a paradigm shift in the learning process, from conventional to contextual, innovative, and learner-centered learning, in line with the philosophy of the Merdeka Curriculum, which emphasizes character building and global competencies (Agung, 2025; Al Idrus, 2022; Yulia et al., 2025). One of the main

challenges in teaching chemistry in senior high school (SMA) is the abstract and theoretical nature of the material, which often causes students to have difficulty relating chemical concepts to everyday life (Dewi et al., 2024; Febriyanti & Siregar, 2025; Putriningtyas, 2025). This phenomenon, which is often reflected in low cognitive learning outcomes and higher-order thinking skills among students, underscores the urgency of adopting more relevant and engaging learning models.

How to Cite:

Hayon, V. H. B., Wariani, T., Tinenti, Y. R., Naen, A. B., Tangi, H., Yasinta Sepe, F., & Derosari, A. M. Analysis of the Implementation of the Integrated Ethnoscience Project-Based Learning (PjBL) Model in NTT Ikat Weaving Dyeing for High School Chemistry Learning. *Jurnal Penelitian Pendidikan IPA*, 12(1), 416-425. <https://doi.org/10.29303/jppipa.v12i1.13874>

On the other hand, East Nusa Tenggara (NTT) is a region rich in cultural heritage, particularly Tenun Ikat, whose manufacturing process, especially at the dyeing stage, is full of local wisdom and contains profound scientific concepts, known as ethnoscience (Siombo, 2019). This wealth of ethnoscience, if utilized optimally, has great potential to become a bridge connecting abstract chemistry concepts with the cultural reality of students, thereby increasing their interest, motivation, and conceptual understanding of chemistry.

The urgency of this research is based on two crucial issues: the need for innovative learning models and the importance of preserving local wisdom through education. Pedagogically, the demand to produce graduates with 21st-century skills—such as problem solving, critical thinking, and collaboration—makes the Project-Based Learning (PjBL) model a highly relevant solution (Lubis et al., 2024; Saba, 2024; Siminto et al., 2025). PjBL provides opportunities for students to design, implement, and evaluate authentic projects, which inherently encourage the development of these skills (Sholeh et al., 2024). However, the effectiveness of PjBL will be maximized when the projects undertaken have a meaningful context for students. Therefore, integrating the ethnoscience of NTT Ikat weaving dyeing into the PjBL framework is very urgent. The traditional ikat weaving dyeing process involves various fundamental chemical concepts, such as coagulation (in the dyeing process), acid-base reactions (in adjusting the pH of the dye), extraction (in obtaining dyes from natural materials), and colloid concepts (in pigment dispersion) (Istikomayanti et al., 2023). Field data and ethnographic studies show that the ikat weaving community in NTT has long applied these chemical principles empirically and traditionally, even though they are not fully aware of them as scientific concepts (Rimbawati, 2023). The use of this local wisdom in PjBL will make chemistry lessons more real, contextual, and indirectly contribute to preserving the NTT ikat weaving culture as a regional identity (Istikomayanti et al., 2023).

A number of previous research results have strengthened the theoretical and empirical basis of this study. Research by Jusita (2019) found that the application of project-based learning models can significantly improve student activity and learning outcomes. Meanwhile, research by Hidayati & Julianto (2025) shows that the integration of an ethnoscience approach in science learning improves students' critical thinking skills, providing a strong indication that ethnoscience is a rich context for cognitive development. Specifically regarding Ikat Weaving, a study by Lalang et al. (2023) identified chemical concepts contained in local cultural products, particularly songke woven fabric. The results showed a connection between the

production of songke woven fabric and chemical concepts, especially in the thread dyeing stage, which involves materials such as reaction rates, acids and bases, and chemical bonds.

The novelty or scientific contribution of this research lies in the comprehensive analysis of the implementation of the integrated ethnoscience PjBL model. This novelty can be seen from the aspects of integration, implementation model, and focus of analysis. First, this study not only uses ikat weaving as a case study, but also systematically integrates the ethnoscience of NTT Ikat Weaving dyeing into all PjBL syntax (from determining basic questions, project design, schedule preparation, to experience evaluation) as a project theme that must produce dyeing products. Second, this study focuses on analyzing implementation at the high school chemistry level, whose concepts are more complex and detailed than those in junior high school science, thus requiring a more in-depth and structured adaptation of PjBL. Third, the novelty lies in the in-depth description of how very specific local wisdom (NTT Ikat Weaving dyeing) can be processed into valid and effective chemistry learning project guidelines, as well as measuring the impact of its implementation, details of which are still rarely explored in the context of education in NTT. Fourth, this study examines the impact, challenges, and strategies for strengthening teacher and student competencies. Thus, this research is expected to produce a tested PjBL implementation model and become a reference for chemistry teachers throughout Indonesia, especially in regions with similar local cultural wealth, to make chemistry learning more relevant, meaningful, and capable of shaping students' cultural and scientific multiliteracy competencies.

The purpose of this study is to comprehensively analyze and describe the implementation of the Project-Based Learning (PjBL) model integrated with the ethnoscience of NTT ikat weaving dyeing in chemistry learning in high schools, including identifying the impacts and challenges and formulating strategies to strengthen the competencies of teachers and students.

Research on the implementation of the Project-Based Learning (PjBL) Model integrated with Ethnoscience in the local context of NTT has strong literature support. The main evidence comes from the article by Dari et al. (2025) which explicitly discusses the integration of Ethnoscience and PjBL to improve students' science process skills. This study validates the conceptual framework that combining these two approaches is effective and relevant. This integration is based on the potential identified by Istikomayanti et al. (2023) regarding the potential of ikat weaving as a source

of Ethnoscience-based learning, which justifies the selection of the topic of NTT ikat weaving.

The context of local wisdom in NTT ikat weaving dyeing is at the core of this study. Siombo (2019) provides a theoretical basis regarding local wisdom in the process of making Timor ikat weaving, which is important for understanding traditional procedures. Furthermore, Lanu (2017) provides practical documentation through the design of a reference book on Traditional Ikat Weaving for Youth in Sikka Regency, which can be directly be used as content reference for student projects.

To connect the tradition of ikat weaving with chemistry concepts in high school, ethnochemistry analysis is needed. The article by Lalang et al. (2023) examines ethnochemistry in Songke woven fabrics in West Manggarai, NTT. This study is very important because it identifies the chemical components in natural dyes. This identification bridges the subjects of Elements, Carbon Compounds, and Redox Reactions, ensuring that the projects carried out by students have sufficient chemical depth.

The implementation of PjBL as the main model is reinforced by empirical evidence of its effectiveness. Bowo (2022); Jusita (2019); Santoso et al. (2024) show that PjBL improves student activity and learning outcomes. Additionally, Siminto et al. (2025) emphasize the role of PjBL in developing creativity and collaborative skills, which are essential skills to be achieved through the weaving dyeing project. These results provide strong indications that integrated ethnoscience PjBL will produce similar positive impacts.

In addition to mastering concepts, this model aims to improve higher-order cognitive skills. Sholeh et al. (2024) specifically found researched that PjBL is effective in improving students' critical thinking skills. In line with this, articles by Dari et al. (2025); Wariani et al. (2025), which focus on the development of ethnoscience-based LKPD for Redox material, show that this integration successfully improves students' science process skills. This is relevant because weaving dyeing involves chemical experiments that require data analysis and critical conclusions.

Two recent studies show the crucial relevance of learning models that integrate local wisdom or ethnoscience into science education, an approach that is particularly important in regional contexts such as East Nusa Tenggara (NTT). Research by Awaluddin (2025) on the application of the Local Wisdom-Based Problem-Based Learning (PBL) Model to environmental pollution material at SMAN 2 Bolo shows that the explicit use of local context is effective in improving students' conceptual understanding because the material becomes more concrete and relevant to their life experiences. In

line with these findings, Lado (2025) through his research on the Ethnoscience-Based Project-Based Learning (PjBL) Model, found a significant positive effect on students' science literacy, indicating that linking scientific principles with traditional cultural practices and knowledge is a powerful strategy for developing critical thinking and science application skills. Overall, these articles confirm that models based on local wisdom serve as a bridge connecting universal science with local culture, making learning more contextual, meaningful, and relevant in efforts to improve the quality of science education in Eastern Indonesia and its surrounding areas.

A review of several articles shows that the implementation of integrated ethnoscience learning models such as PjBL (Project-Based Learning) focusing on NTT ikat weaving dyeing poses significant challenges that require planned strategies to strengthen teacher competencies. Specifically, Hayon et al. (2025) highlight the need to improve prospective chemistry teachers' perceptions and readiness for NTT culture-based contextual learning (ethnoscience), indicating that cultural integration is still a new area that requires training and familiarization. This challenge is reinforced by Nuraeni et al. (2024), who analyze that although science teachers have a positive perception of STEAM-PjBL-oriented learning with local wisdom content, the implementation of this innovative model requires additional competencies from teachers, especially in designing projects that truly integrate science with elements of local wisdom in depth. Therefore, strategies to strengthen teacher competencies must focus on continuous training in the design of PjBL projects that are valid in terms of ethnoscience and the development of teaching materials that connect chemistry concepts (e.g., colloids or dyes) with the cultural richness of NTT, to ensure effective and optimal implementation.

The aspects of challenges and strengthening teacher competencies are very important in the implementation of the new model. Nuraeni et al. (2024) analyzed science teachers' perceptions of PjBL with local wisdom content, identifying teachers' readiness, obstacles, and professional development needs.

Overall, this scientific article provides a comprehensive foundation and confirms the effectiveness of PjBL, provides specific NTT (ikat weaving) ethnochemistry content, supports learning impact analysis (cognitive and skills), and most importantly, provides insights to identify challenges and strategies for strengthening teacher and student competencies.

In general, the literature shows a strong consensus regarding the effectiveness of the PjBL Model and the integration of ethnoscience/local wisdom in science

learning, both in improving cognitive learning outcomes and 21st-century skills such as critical thinking, collaboration, and scientific process skills (Dari et al., 2025; Sholeh et al., 2024). Another consistency lies in the potential of ethnochemistry in fabric dyeing as a bridge to high school chemistry materials (Istikomayanti et al., 2023; Lalang et al., 2023). However, differences and challenges arise in the dimensions of implementation and scope of analysis. Some studies show the effectiveness of locally based PBL (Problem-Based Learning), while others specifically emphasize the advantages of PjBL with a focus on project products, indicating a variety of integrated models being tested. In addition, the literature highlights consistent challenges related to teacher readiness in designing integrated curricula and limited access to local resources (Nuraeni et al., 2024; Riskayanti, 2023; Widiansyah et al., 2025), although these challenges tend to be general (national) and not specific to the socio-academic conditions of chemistry teachers in NTT.

Although the theoretical foundation is strong, there are significant gaps that need to be filled by this study. The main gap is the lack of in-depth and empirical analysis of the actual implementation of the integrated PjBL model of NTT ikat weaving ethnosience in high school chemistry lessons. Most of the positive findings come from studies outside NTT or use different local wisdom objects. The second gap is the absence of specific data on the comparative impact of the PjBL model integrated with Ethnosience vs. pure PjBL, which is needed to isolate the effect of NTT local wisdom itself on motivation, learning outcomes, or skills. Finally, a critical gap is the need to formulate measurable and contextual strategies for strengthening teacher and student competencies that directly address the specific challenges faced by the academic community in East Nusa Tenggara in managing complex weaving dyeing projects.

This research is supported by three main theoretical pillars: Constructivism, the PjBL Model, and the Concept of Ethnosience. Theoretically, Constructivism serves as a philosophical foundation, stating that students actively construct their understanding through real experiences. In this context, PjBL (Independent Model) becomes the methodological structure that guides students through the NTT ikat weaving coloring project (Context/Content Variable) through organized stages (e.g., planning, implementation, product evaluation). The key relationship is that PjBL facilitates the integration of Ethnosience content; abstract Chemistry concepts (Redox, Colloids, Carbon Compounds) are made contextual and empirical through the traditional dyeing process. This active process will then be analyzed for its impact on the

Dependent Variable (Student Learning Outcomes/Competencies), such as improved critical thinking and scientific process skills, as well as their understanding of local wisdom values.

The application of theory in this study will focus on analyzing how and why the implementation of the model is effective (or not). The PjBL theory will be used to verify the suitability of the implementation stages in the classroom with the theoretical standards of PjBL, as well as to measure the impact of the project on improving student competence. Meanwhile, the concept of ethnosience will be applied to analyze the relevance of chemistry content extracted from the NTT weaving dyeing process (ethnochemistry) and to measure students' perceptions of the contextuality of the material. If challenges arise, constructivism theory will help analyze failures in the learning process (e.g., lack of scaffolding or projects that are too far from students' prior knowledge), which will then form the basis for formulating competency-strengthening strategies for teachers and students.

Method

This study uses a quantitative descriptive approach. According to Sugiyono (2017), a quantitative descriptive approach serves to describe the characteristics or views of a group of people in a population systematically and based on the facts found. This research will be conducted in 5 districts/cities in NTT, namely Rote district, Sabu Raijua district, Lembata district, East Flores district, and Kupang city. The research stages include the preparation stage, data collection, data analysis, and research report preparation. Data collection will be carried out in the odd semester of the 2025/2026 academic year.

The subjects of this study were five chemistry teachers and 100 students from high schools in five districts/cities in NTT, namely Rote District, Sabu Raijua District, Lembata District, East Flores District, and Kupang City. The sampling technique used in this study was purposive sampling. This technique was chosen because the researcher needed to take samples based on certain criteria set by the researcher. In this case, the criteria included: chemistry teachers at high schools in 5 districts/cities and students from those 5 schools who were in the 12th grade in the odd semester and were studying acids and bases in their curriculum. This study was conducted with the aim of comprehensively analyzing and describing the implementation of the Project-Based Learning (PjBL) model integrated with the ethnosience of NTT ikat weaving dyeing in chemistry learning in high schools, including identifying the impacts and challenges and formulating strategies to

strengthen the competencies of teachers and students. Furthermore, by involving samples from several regional clusters, the research findings can be more generalized and considered representative of the context of high school chemistry learning in the NTT region as a whole, not limited to one location.

Data collection was carried out using five research instruments, namely observation sheets on the implementation of integrated PjBL and ethnoscience, teacher questionnaires, student questionnaires, teacher interview guidelines, and student interview guidelines. The observation sheet was used to obtain quantitative data on the level of implementation of the PjBL syntax and the integration of ethnoscience in learning. The student questionnaire provided information about learning experiences, obstacles encountered, and the impact of learning on students' science literacy. In-depth interviews with teachers and students were used to explore quantitative findings further, especially those related to experiences, obstacles, and strategies during project implementation. The questionnaire was distributed online via Google Form, while observations were conducted by two observers in each school and interviews were conducted by telephone.

Quantitative data from observations and questionnaires were analyzed using descriptive statistics in the form of percentages, means, and standard deviations, which were then interpreted into specific categories. Meanwhile, qualitative data from interviews were analyzed using the Miles and Huberman analysis model, which included data reduction, data presentation, and conclusion drawing. To improve the validity of the findings, this study applied instrument triangulation by comparing data from observations, questionnaires, and interviews. All instruments were validated by three chemistry education experts and deemed suitable for use.

Results and Discussion

Teachers' perceptions and self-efficacy regarding the implementation of the integrated PjBL Model of Ethnoscience are in the good category with an average score of 4.08, reflecting teachers' positive beliefs about the relevance of the model and its benefits for improving teaching competence. However, the indicators of challenges and implementation constraints received an average score of 2.88 and were in the not good category, indicating that teachers faced significant obstacles, particularly related to time constraints, logistics, the absence of standard teaching materials, and the difficulty of integrating the weaving dyeing process into a dense curriculum structure. On the indicators of strengthening strategies and reflective efforts, teachers

gave a rating in the good category with an average of 3.68, indicating that despite considerable challenges, teachers have made efforts to develop adaptive strategies such as collaboration with local artisans, schedule modifications, and improvements to project designs to make them more contextually appropriate as represented in Table 1.

Table 1. Teacher questionnaire results

Indicator Group	Group Average (\bar{x})	Group Standard Deviation (σ)	Interpretation
A	4.08	0.78	Good
B	2.88	1.04	Not Good
C	3.68	1.09	Good

The implementation of the integrated PjBL Model of Ethnoscience in NTT Ikat Weaving Dyeing received very positive responses in two main aspects, namely the positive impact on science-culture literacy ($\bar{x} = 4.31$; SD = 0.50) and the role of teachers and learning strategies ($\bar{x} = 4.44$; SD = 0.49), both of which are in the Very Good category as shown in Table 2.

Table 2. Students' questionnaire results

Aspect	Component Average (\bar{x})	Standard Deviation (SD)	Interpretation
A	4.31	0.50	Very Good
B	3.03	0.61	Enough
C	4.44	0.49	Very Good

These findings indicate that students felt an increase in their contextual understanding of chemistry concepts, their involvement in learning, and effective teacher guidance during the project implementation. However, the aspects of challenges and obstacles in project implementation received the lowest average score ($\bar{x} = 3.03$; SD = 0.61) in the fair category, indicating that students still faced various obstacles such as limited tools and materials, project time management, and difficulties in connecting abstract chemistry concepts with traditional weaving dyeing practices.

Table 3 shows the implementation of the integrated PjBL Model of Ethnoscience. The observation results show that all stages of PjBL went well, marked by the exploration of local culture, demonstrations of natural coloring, and practical activities that connected chemical concepts with traditional practices. These findings are in line with the results of the student questionnaire, which showed that they felt highly motivated and considered hands-on experiences to be the most interesting and meaningful component of learning.

Table 3. PjBL implementation

Data Source	Relevant Key Findings	Consistency (Connection)
Observation (PjBL Process)	The Ethnoscience PjBL process was carried out, involving cultural exploration and chemistry practices (e.g., dyeing demonstrations).	The observed process (Observation) was confirmed by Teacher Interviews (effective strategies are practice and visualization) and Student Questionnaires (high motivation due to the relevance of the practice).
Student Questionnaire (Experience)	Students reported high motivation and hands-on experience as the best part.	Students appreciate the practical and contextual aspects observed in the field.
Teacher Interviews (Implementatio)	Teachers apply structured scaffolding and use visual analogies to bridge concepts.	Effective teacher strategies support positive student experiences and are consistent with what was observed.

Teacher interviews further confirmed this consistency, with teachers explaining that they used structured scaffolding and visual analogies to help students understand concepts, strategies that were shown to support student engagement and understanding as reflected in the questionnaire and

observation data. The alignment of these three data sources reinforces that ethnoscience-based PjBL is not only well implemented but also effective in creating chemistry learning that is relevant, contextual, and motivating for students.

Table 4. Constraints and challenges

Data Source	Relevant Key Findings	Consistency (Correlation)
Teacher Questionnaire (Challenges)	The score for Aspect B (Challenges) was classified as Fair (average $X = 3.03$), driven by low scores for P7 (Availability of Resources) and P8 (Time Management).	The teacher questionnaire quantitatively showed that time and resource issues were the main weaknesses.
Teacher Interviews (Constraints)	Teachers mentioned that the main constraints were time limitations, difficulties in providing sufficient weaving materials, and problems with coordinating resource persons (Technical/Non-Academic Constraints).	The teacher interviews explained the time and resource constraints identified in the Teacher Questionnaire.
Student Questionnaire (Constraints)	Students also reported logistical difficulties related to schedule conflicts, limited exploration time, and difficulties in finding raw materials (Student Technical/Non-Academic Constraints).	The constraints complained about by students (logistics, time, materials) were qualitatively identical to those reported by teachers, validating that these constraints were real and disruptive to both parties.

Table 4 shows that the main challenges in implementing integrated PjBL in Ethnoscience consistently stem from time and resource constraints, as reflected in various data sources. The teacher questionnaire placed the Challenge Aspect in the Fair category ($\bar{x} = 3.03$), mainly influenced by low scores on the indicators of resource availability (P7) and time management (P8), which indicate that these two aspects are the most significant obstacles. Consistency is seen in the results of teacher interviews, which qualitatively confirm these constraints, including difficulties in providing natural Tenun Ikat dyeing materials, limited learning time, and the need for coordination with resource persons or local craftsmen. These findings are also reinforced by student questionnaires, which report similar obstacles, such as schedule conflicts, inadequate practice time, and difficulties in obtaining raw materials, showing that these obstacles are felt by both parties.

Table 5 shows that the implementation of integrated PjBL Etnosains has a strong positive impact

on students' learning outcomes and science-culture literacy. Questionnaire data shows that the Positive Impact and Teacher Role aspects received very high average scores ($\bar{x} > 4.2$), reflecting an increase in motivation, conceptual understanding, and the quality of learning interactions. These quantitative findings are reinforced by student interviews, which reveal that they not only better understand chemistry concepts related to dyes and solutions, but also begin to see Tenun Ikat as a cultural practice with a scientific basis, thereby enriching their perspectives on science and local culture. Teacher interviews showed similar results, namely that students were able to connect chemistry theory with ethnoscience applications more systematically and demonstrated an increase in soft skills such as cooperation, communication, and creativity while carrying out the project. Thus, the Ethnoscience PjBL model not only improves academic achievement but also deepens science-culture literacy and strengthens students'

holistic competencies through contextual learning experiences.

Table 5. Impact and learning outcomes

Data Source	Relevant Key Findings	Consistency (Correlation)
Student Questionnaire (Cultural-Scientific Literacy)	Aspect A (Positive Impact) and Aspect C (Teacher Role) received a rating of Very Good (average $X > 4.2$).	High scores on the questionnaire indicate a positive impact, which was further explained by the interviews.
Student Interviews (Impact)	Students reported increased motivation, understanding of the concept of Colored Substances/Solutions (Motivation & Conceptual Understanding), and a change in their views on Ikat Weaving (Cultural Relevance).	The student interviews validated the Student Questionnaire scores by explaining how and what had changed in their understanding, from mere heritage to scientific application.
Teacher Interviews (Impact)	Teachers noted that students successfully linked theoretical chemistry with local culture (Student Challenges) and demonstrated improvement in soft skills (Teacher Role/Strategy).	Teachers confirmed that the core objective (linking chemistry and culture) was achieved, supporting the findings of positive impact.

Discussion

The results of this study indicate that the application of the Project-Based Learning (PjBL) model integrated with Ethnoscience of NTT Ikat Weaving Dyeing is able to increase the relevance of chemistry learning and significantly encourage active student engagement. The high level of PjBL syntax implementation based on observations, student questionnaires, and teacher interviews indicates that the use of cultural context as a project basis provides an effective anchoring experience for understanding abstract chemistry concepts. These findings are consistent with previous studies by Djarwo et al. (2025); Sari & Ernawati (2025); Wiraningtyas (2024), which show that the integration of ethnoscience in chemistry learning can improve the connection between concepts and students' real experiences. Additionally, studies by, and Abdurahman et al. (2024); Handayani & Supardi (2025); Srihartini et al. (2025), also report that PjBL improves problem-solving skills and learning motivation when locally-based projects are implemented. Thus, the results of this study reinforce the evidence that locally-based PjBL can be an effective pedagogical strategy for enhancing the meaning of learning.

The obstacles encountered in this study, such as time constraints, availability of materials, and field coordination challenges, are in line with the findings of previous studies. For example, studies by Putri et al. (2025); Sari (2025) show that the implementation of PjBL requires more time and resource readiness for the project to run optimally. These findings are reinforced by studies by Sitizahratul Aini (2025); Thayban et al. (2025), which conclude that ethnoscience-based learning often faces logistical obstacles and limitations in local materials if it is not supported by access to resources and

community collaboration. The consistency of these findings confirms that the obstacles that arise do not originate from the learning model itself, but from external factors that require institutional support and careful planning.

In terms of impact, the results of this study reveal that students experienced an increase in motivation, understanding of the concepts of dyes and solutions, and a change in their perspective on Tenun Ikat as a cultural heritage with a scientific basis. This is in line with the findings of Wirasti (2024), which show that ethnoscience-based chemistry learning can improve science-culture literacy and encourage a deeper understanding of concepts because students see a direct connection between their culture and science. Additionally, research by Putri et al. (2025) found that PjBL improves soft skills such as cooperation and creativity, which was also observed in this study through interviews with teachers who mentioned an increase in students' collaborative skills.

The role of teachers as facilitators is crucial to the success of this learning, as indicated by the high scores given by students on the aspect of teacher guidance. These findings are consistent with the study by Syafila & A'yun (2024), which confirms that the success of PjBL is highly dependent on the teacher's ability to provide scaffolding, manage projects, and connect scientific concepts to real-world contexts. Thus, this study reinforces the literature that PjBL is not only about the projects that students do, but also about how teachers design meaningful learning experiences.

Overall, this study not only supports but also expands on previous findings by showing that the integration of PjBL and NTT Ikat Weaving-based ethnoscience has strong potential to improve students' understanding of chemistry concepts, motivation,

science-culture literacy, and 21st-century competencies. However, implementation challenges remain consistent with the patterns of obstacles that have been widely reported in previous studies, requiring school policy support, the provision of local resources, and strengthened collaboration with cultural communities to maintain the sustainability and effectiveness of this learning model.

Conclusion

The results of the study show that the implementation of the Project-Based Learning (PjBL) Model integrated with the ethnoscience of NTT Ikat Weaving Dyeing proved to be effective in improving the quality of the chemistry learning process and outcomes in high schools. The implementation of the PjBL syntax was in the very good category and was consistently supported by student experiences and teacher pedagogical strategies, which created contextual, meaningful learning and encouraged active engagement. The integration of ethnoscience proved to strengthen the understanding of chemistry concepts, particularly materials related to dyes and solutions, while also improving students' science-culture literacy through the connection between scientific concepts and local cultural heritage. However, this study also revealed major challenges in the form of time constraints, logistics, and the availability of practical materials, which impacted the smooth running of the project. Overall, this study confirms that ethnoscience-based PjBL is a relevant and promising approach to be applied more widely in chemistry learning. However, its success requires stronger institutional support, coordination, and planning to ensure its sustainability and optimal results.

Acknowledgment

The authors would like to express their gratitude everyone involved in this research both directly and indirectly.

Author Contribution

This article was written by seven authors, namely V. H. B.H., T. W., Y. R. T., A. B. N., H. T., F. Y. S., and A. M. D. All authors carried out each stage of the research together.

Funding

This research did not receive external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

- Abdurahman, A., Christine, S. E., & Pradesa, K. (2024). Persepsi Siswa terhadap Pembelajaran Berbasis Proyek dalam mata pelajaran Kimia: Analisis Kualitatif di SMA Ramu Bogor. *Jurnal BELAINDIKA (Pembelajaran Dan Inovasi Pendidikan)*, 6(3), 330-341. <https://doi.org/10.52005/belaindika.v6i3.298>
- Agung, B. (2025). Transformasi Kurikulum Merdeka: Analisis Filosofis dan Implikasinya terhadap Pembentukan Karakter Peserta Didik. *Nizamiyah: Jurnal Sains, Sosial Dan Multidisiplin*, 1(2), 92-104. <https://doi.org/10.64691/nizamiyah.v1i2.41>
- Al Idrus, S. W. (2022). Implementasi STEM terintegrasi etnosains (Etno-STEM) di Indonesia: Tinjauan meta analisis. *Jurnal Ilmiah Profesi Pendidikan*, 7(4), 2370-2376. <https://doi.org/10.29303/jipp.v7i4.879>
- Awaluddin, R. (2025). Penerapan Model Problem Based Learning (PBL) Berbasis Kearifan Lokal pada Materi Pencemaran Lingkungan Untuk Meningkatkan Pemahaman Siswa Kelas X di SMAN 2 Bolo. *Jurnal Jendela Pendidikan*, 5(02), 312-321. <https://doi.org/10.57008/jjp.v5i02.1340>
- Bowo, B. (2022). Meningkatkan Aktivitas Belajar Kimia Materi Reaksi Redoks Menggunakan Model PjBL di Madrasah Aliyah. *Indonesian Journal of Action Research*, 1(2), 177-187. <https://doi.org/10.14421/ijar.2022.12-06>
- Dari, R. K., Hamidah, A., & Anggreini, E. (2025). Integrasi Pembelajaran Berbasis Etnosains Terhadap Keterampilan Proses Sains Siswa Menggunakan Model Pembelajaran Project Based Learning: (Integration of Ethnoscience-Based Learning on Students' Science Process Skills Using the Project Based Learning Model. *BIODIK*, 11(03), 485-493. <https://doi.org/10.22437/biodik.v11i03.45834>
- Dewi, E. K., Suriswo, S., & Muljani, S. (2024). Pengembangan Bahan Ajar IPAS Menggunakan Metode Project Based Learning Bermuatan Etnosains untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa SD. *Journal of Education Research*, 5(3), 3095-3102. <https://doi.org/10.37985/jer.v5i3.1419>
- Djarwo, C. F., Inggamer, M. M., Rumbrapuk, A. J., & Astuti, N. (2025). Analisis literasi digital berbasis etnosains dalam pembelajaran kimia untuk meningkatkan pemahaman konsep dan motivasi belajar mahasiswa. *Jurnal Pendidikan Dan Pembelajaran IPA Indonesia*, 15(1), 62-77. <https://doi.org/10.23887/jppii.v15i1.93346>
- Febriyanti, A., & Siregar, A. D. (2025). Analisis Kesulitan Belajar Siswa dalam Penerapan Kurikulum Merdeka Pada Pembelajaran Kimia Kelas X di SMA Negeri 1 Kerinci. *Jurnal Riset Pendidikan Kimia (JRPK)*, 15(1), 69-76.

- <https://doi.org/10.21009/JRPK.151.07>
- Handayani, D., & Supardi, U. S. (2025). The Effectiveness of a Project-Based Scientific Approach on Creative Thinking Skills and Students Chemistry Problem-Solving Ability. *COSMOS: Jurnal Ilmu Pendidikan, Ekonomi Dan Teknologi*, 2(4), 787-801. Retrieved from <https://cosmos.iainsambas.ac.id/index.php/cms/article/view/297>
- Hayon, V. H. B., Wariyani, T., Tinenti, Y. R., Mukin, M. U. J., & Naen, A. B. (2025). Persepsi Calon Guru Kimia Terhadap Implementasi Pembelajaran Kontekstual Berbasis Budaya (Etnosains) NTT dalam Pembelajaran Kimia. *Jurnal Locus Penelitian Dan Pengabdian*, 4(11), 10194-10208. <https://doi.org/10.58344/locus.v4i11.4888>
- Hidayati, F., & Julianto, J. (2025). Integrasi Pendekatan Etnosains dalam Pembelajaran Sains untuk Meningkatkan Keterampilan Berpikir Kritis Siswa. *DIDAKTIKA: Jurnal Pemikiran Pendidikan*, 31(1), 101-112. <https://doi.org/10.30587/didaktika.v31i1.9578>
- Istikomayanti, Y., Aldya, R. F., Djarawula, E., & Malo, A. R. (2023). Potensi Tenun Ikat Sebagai Sumber Belajar Berbasis Etnosains. *Jurnal Ilmiah Biosaintropis (Bioscience-Tropic)*, 8(2), 104-114. <https://doi.org/10.33474/e-jbst.v8i2.519>
- Jusita, M. L. (2019). Implementasi model pembelajaran berbasis proyek (project based learning) untuk meningkatkan aktivitas dan hasil belajar siswa. *Jurnal Teori Dan Praksis Pembelajaran IPS*, 4(2), 90-95. <https://doi.org/10.17977/um022v4i22019p090>
- Lado, S. P. U. (2025). Pengaruh Model Pembelajaran Project Based Learning (PjBL) Berbasis Etnosains Terhadap Literasi Sains Siswa Di Sma (Slua) Saraswati 1 Denpasar. *Universitas Mahasaraswati Denpasar*. Retrieved from <https://shorturl.asia/Mp8Pf>
- Lalang, A. C., Christianto, H., Lestarani, D., Parera, L. A. M., & Murni, M. M. (2023). Etnokimia Pada Kain Tenun Songke Asal Desa Kakor Kecamatan Lembor Selatan Kabupaten Manggarai Barat, Nusa Tenggara Timur. *Jurnal Beta Kimia*, 3(2), 15-28. <https://doi.org/10.35508/jbk.v3i2.13602>
- Lanu, V. (2017). Perancangan Buku Referensi Pembuatan Tenun Ikat Tradisional Bagi Kalangan Remaja Di Kabupaten Sikka Kepulauan Flores Sebagai Bentuk Pelestarian Budaya Lokal. *Institut Bisnis dan Informatika STIKOM Surabaya*. Retrieved from <https://repository.dinamika.ac.id/id/eprint/2292/>
- Lubis, D. C., Harahap, F. K. S., Syahfitri, N., Sazkia, N., & Siregar, N. E. (2024). Pembelajaran berbasis proyek: Mengembangkan keterampilan abad 21 di kelas. *Edu Society: Jurnal Pendidikan, Ilmu Sosial Dan Pengabdian Kepada Masyarakat*, 4(1), 1292-1300. <https://doi.org/10.56832/edu.v4i1.472>
- Nuraeni, M. I., Wahyuni, S., & Mudakir, I. (2024). Analisis Presepsi Guru IPA Terhadap Pembelajaran Berorientasi STEAM-PJBL Bermuatan Kearifan Lokal. *Jurnal Pendidikan Dan Pembelajaran IPA Indonesia*, 14(3), 120-127. <https://doi.org/10.23887/jppii.v14i3.78956>
- Putri, N. M., El Hakim, L., & Ristanto, R. H. (2025). Studi Literatur Penerapan Project-Based Learning (PjBL) Pada Pembelajaran Kimia. *Ideguru: Jurnal Karya Ilmiah Guru*, 10(1), 433-442. <https://doi.org/10.51169/ideguru.v10i1.1251>
- Putriningtyas, K. (2025). Penerapan Etnosains-Project Based Learning untuk Meningkatkan Keterampilan Berpikir Kritis pada Materi Bumi dan Tata Surya di SMPN 18 Surakarta. *Universitas Sebelas Maret*. Retrieved from <https://digilib.uns.ac.id/dokumen/detail/122574/>
- Rimbawati, P. R. N. (2023). *Perempuan dan Ekonomi Kreatif Tenun: Perspektif Gender*. Jakarta: Penerbit BRIN.
- Riskayanti, Y. (2023). Penerapan pendekatan stem project based learning untuk meningkatkan hasil belajar kimia. *Prosiding Temu Ilmiah Nasional Guru*, 15(1), 466-474. <https://doi.org/10.33830/ting.v15i1.2274>
- Saba, A. A. (2024). Efektivitas pembelajaran project based learning dalam meningkatkan kreativitas dan keterampilan berpikir kritis siswa. *Journal Sains and Education*, 2(02), 40-46. <https://doi.org/10.59561/jse.v2i02.384>
- Santoso, A., Nurkhotimah, A. N., & Harintosasi, R. (2024). Meningkatkan keaktifan dan hasil belajar pada materi struktur atom dan nanoteknologi dengan menerapkan model pembelajaran project-based learning (PjBL). *Jurnal Kajian Pendidikan Indonesia*, 1(1). Retrieved from <http://appijournal.org/index.php/jkpi/article/download/8/7>
- Sari, N. I. (2025). Kemampuan Berpikir Analitis Dalam Pendidikan Kimia Melalui Stem-Pjbl: Tinjauan Literatur. *Macca: Science-Edu Journal*, 398-409. <https://doi.org/10.51574/msej.v2i2.3393>
- Sari, T. E. P., & Ernawati, T. (2025). Analisis Etnosains Dalam Pembelajaran IPA Sebagai Sumber Belajar Yang Inovatif Bagi Siswa Kelas VII: Kajian Literatur. *Jurnal Pendidikan MIPA*, 15(1), 265-274. <https://doi.org/10.37630/jpm.v15i1.2498>
- Sholeh, M. I., Tasya, D. A., Syafi'i, A., Rosyidi, H., Arifin, Z., & binti Ab Rahman, S. F. (2024). Penerapan

- pembelajaran berbasis proyek (PjBL) dalam meningkatkan kemampuan berpikir kritis siswa. *Jurnal Tinta*, 6(2), 158-176. <https://doi.org/10.35897/jurnaltinta.v6i2.1484>
- Siminto, S., Majdi, M., Hardiansyah, A., Rofi'i, A., & Gazali, A. (2025). Pembelajaran Berbasis Proyek: Mengembangkan Kreativitas Dan Kemampuan Kolaboratif. *Jurnal Pendidikan Dan Keguruan*, 3(4), 308-320. Retrieved from <https://jutepejoln.net/index.php/JURPERU/article/view/52>
- Siombo, M. R. (2019). Kearifan Lokal Dalam Proses Pembuatan Tenun Ikat Timor (Studi Pada Kelompok Penenun Di Atambua-Ntt). *Bina Hukum Lingkungan*, 4(1), 97-112. Retrieved from <https://bhl-jurnal.or.id/index.php/bhl/article/view/105>
- Sitizahratul Aini, S. A. (2025). Efektivitas Penerapan Model Project Based Learning (Pjbl) Era Kurikulum Merdeka Terhadap Kemampuan Kognitif Siswa Di Sman 1 Wonomulyoefektivitas Penerapan Model Project Based Learning (Pjbl) Era Kurikulum Merdeka Terhadap Kemampuan Kognitif Siswa Di Sman. *Universitas Sulawesi Barat*. Retrieved from <https://repository.unsulbar.ac.id/id/eprint/2100>
- Srihartini, Y., Maryam, S., & Rihma, W. A. (2025). Model Pembelajaran Project Based Learning (PjBL) dan Peningkatan Keterampilan Abad 21 Peserta Didik. *At-Tadris: Journal of Islamic Education*, 4(2), 297-306. <https://doi.org/10.56672/kyxbps82>
- Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.
- Syafila, A. E., & A'yun, D. Q. (2024). Analisis eksplorasi konsep pendidikan konstruktivis dalam pembelajaran berbasis proyek. *Jurnal Media Akademik (JMA)*, 2(12). <https://doi.org/10.62281/v2i12.1175>
- Thayban, T., Rajak, S. Y., Lukum, A., Kunusa, W. R., & Munandar, H. (2025). Meningkatkan Keterampilan Berpikir Kreatif dalam Pendidikan Kimia: Peran Model Pembelajaran Aktif dan Integrasi STEM. *Jurnal Entropi*, 20(1), 52-63. <https://doi.org/10.37905/je.v20i1.32573>
- Wariani, T., Hayon, V. H. B., Mukin, M. U. J., & Naen, A. B. (2025). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Etnosains Materi Redoks, Sel Volta, dan Elektrolisis. *Jurnal Locus Penelitian Dan Pengabdian*, 4(5), 2207-2226. <https://doi.org/10.58344/locus.v4i5.4092>
- Widiansyah, S., Hidayat, S. P., Kamil, S. I., Purba, I. D. L. B., Rahmawati, U., & Khairo, F. M. A. (2025). Kesiapan Guru dalam Menghadapi Tantangan Implementasi Kurikulum Merdeka:(Studi Kasus di Sekolah Menengah Atas). *Harmoni Pendidikan: Jurnal Ilmu Pendidikan*, 2(1), 344-362. <https://doi.org/10.62383/hardik.v2i1.1120>
- Wiraningtyas, A. (2024). Constructivism Through Problem-Based Learning (PBL) in Chemistry Education with Ethnoscience Content. *Chemistry Education Practice*, 7(2), 366-375. Retrieved from <https://jurnalfkip.unram.ac.id/index.php/CEP/article/view/7998>
- Wirasti, H. (2024). Pembelajaran Kimia Berbasis Etnosains Pada Batik Sekar Jagad Kebumen Untuk Menumbuhkan Nilai Karakter Sikap Peduli Lingkungan Siswa. *Jurnal Semarak Kabumian*, 2(1), 30-38. Retrieved from <https://jurnal.kebumenkab.go.id/index.php/jsk/article/view/277>
- Yulia, N. M., Salsabila, A. D., & Anggita, A. L. I. (2025). Analisis Penerapan Model Project Based Learning Berbasis Etnosains pada Pembelajaran IPA di Sekolah Dasar. *Madrasah Ibtidaiyah Education Journal*, 3(1), 11-20. <https://doi.org/10.63321/miej.v3i1.96>