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Sagu Sep Ethnoscience-Based Science Worksheet: Enhancing Critical Thinking Skills among Elementary School Students

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ABSTRACT

This study examined changes in elementary students' critical thinking skills after learning with a Sagu Sep ethnoscience-based science worksheet. A quantitative pre-experimental study was conducted using a one-group pre-test-post-test design with 20 fifth-grade students at SD Negeri 2 Merauke, South Papua, Indonesia. Data were collected using a critical-thinking test covering five indicators: formulating problems, constructing evidence-based arguments, collecting and representing data, making logical interpretations, and evaluating information based on facts or principles. Data were analyzed using descriptive percentages and group normalized gain (N-Gain). The group mean score increased from 0.00% on the pre-test to 89.23% on the post-test, yielding an N-Gain of 0.89, categorized as high. All five indicators were in the high category, with N-Gain values from 0.85 to 1.00. The findings suggest that the Sagu Sep ethnoscience-based worksheet provided a meaningful contextual setting for students to engage in scientific reasoning and critical-thinking activities. The study contributes empirical evidence for integrating South Papuan cultural knowledge into elementary science learning materials.

INTRODUCTION

Science learning in elementary schools is expected to develop not only conceptual understanding but also higher-order thinking skills, including critical thinking. Critical thinking involves identifying problems, examining evidence, constructing explanations, interpreting information, and evaluating claims against relevant criteria. Contextual learning is important because abstract presentation of science concepts can limit opportunities for students to connect scientific

reasoning with phenomena encountered in everyday life. Local knowledge can provide such contexts because cultural practices contain observable phenomena, procedures, environmental knowledge, and problem-solving strategies that can be related to school science (Adawiah et al., 2026; Kasi et al., 2024).

Ethnoscience provides a framework for bringing community knowledge into science learning without reducing culture to supplementary information. In an ethnoscience approach, cultural practices are examined as potential sources of scientific phenomena and are transformed into learning activities that invite students to observe, question, investigate, reason, and evaluate. Recent studies indicate that ethnoscience and local-wisdom-based learning can support critical thinking, scientific literacy, cultural literacy, and science process skills in school science(Juhariyani & Atmojo, 2025; MUH, 2024; Munira et al., 2024). A recent review likewise shows that local wisdom in elementary science learning may provide contexts related to nature, food processing, technology, traditions, and other community practices, with reported benefits for higher-order thinking and science learning (Adawiah et al., 2026).

The pedagogical value of ethnoscience can be enhanced by incorporating local knowledge into structured instructional materials designed to develop students' critical thinking and cultural understanding. Ethnoscience-based project learning materials have been associated with substantial gains in students' critical thinking skills, as indicated by N-Gain analysis (Hanum et al., 2023). Similarly, a contextual science e-module integrating local wisdom has been reported to support the development of critical thinking skills (Hidayat et al., 2024). In elementary science education, instructional materials based on local wisdom have also been identified as a means of supporting students' critical thinking development (Azura et al., 2023). Furthermore, a science e-module incorporating local wisdom has been reported to improve students' cultural literacy and critical thinking skills (Wahyudi et al., 2025). More recent worksheet studies have also demonstrated the potential of culturally contextualized materials, including the Ethno-STEAM-based Si PURI worksheet and digital ethnoscience-based student worksheets(Indra et al., 2026; Purnawati et al., 2026). These findings suggest that the instructional value of local wisdom depends not only on the cultural content selected but also on how that content is organized into activities that require students to construct and evaluate knowledge.

Local wisdom can be integrated into science learning through various instructional strategies and assessment approaches to enhance students' critical thinking and science process skills. The integration of ethnoscience into contextual teaching and learning has been shown to support the development of critical thinking skills in elementary science education (Juhariyani & Atmojo, 2025). Similarly, incorporating local wisdom into problem-based multimedia can promote students' critical thinking skills (Pratiwi et al., 2024). Furthermore, a guided inquiry module based on local wisdom can facilitate the development of science process skills by engaging students in systematic investigations and data collection (Rahmawati et al., 2026). The importance of explicitly assessing critical thinking is also emphasized, who developed or examined assessment approaches for critical-thinking constructs in science learning (Cahayu et al., 2024; Dini & Kuswanto, 2025). Reviews of local-wisdom research further indicate that reported outcomes vary according to the learning medium, instructional strategy, cultural context, and indicators assessed (Aliyah et al., 2026; Rahmawati et al., 2026)

The South Papua region provides valuable opportunities for developing culturally responsive science learning grounded in local knowledge and practices. The Malind community possesses diverse forms of local knowledge concerning natural resources, food processing, environmental interactions, traditional practices, and relationships with the natural environment. Ethnoscientific knowledge documented in South Papuan communities has been identified as a relevant resource for connecting local cultural practices with school science learning (Rapsanjani et al., 2025). One example is Sagu Sep, a traditional food-processing practice associated with Papuan communities that offers opportunities to explore scientific concepts through everyday cultural activities. The process of making Sagu Sep involves scientific phenomena, particularly heat transfer, making it a potential contextual medium for science learning (Supriyadi et al., 2020). Accordingly, Sagu Sep can serve not only as a cultural learning resource but also as an observable phenomenon through which elementary school students can investigate scientific processes, examine cause-and-effect relationships, and connect scientific concepts with their local environment.

Despite the growing literature on ethnoscience and local wisdom, several gaps remain. First, empirical studies using cultural practices from South Papua, particularly Malind contexts, as the basis

for elementary science worksheets remain limited (Rapsanjani et al., 2023). Second, many studies focus on the development, feasibility, or general effectiveness of learning materials, whereas fewer examine distinct critical-thinking processes such as problem formulation, evidence-based argumentation, data representation, logical interpretation, and evaluation within one culturally specific context. Third, recent evidence suggests that the contribution of local wisdom is influenced by the design of the learning resource and the competencies assessed (Rhamadani et al., 2026; Shafnahriyah & Sukarmin, 2026; Syarifuddin et al., 2024). These gaps indicate the need for empirical studies that connect a specific South Papuan cultural practice with clearly defined critical-thinking activities.

The present study addresses this gap by implementing a Sagu Sep ethnoscience-based science worksheet with fifth-grade elementary school students at SD Negeri 2 Merauke. The worksheet uses Sagu Sep as a contextual phenomenon and guides students through activities involving problem formulation, evidence-based argumentation, data collection and representation, logical interpretation, and evaluation. The study aims to examine changes in students' critical thinking skills following the intervention. By focusing on these five indicators, the study seeks to provide more specific evidence of how a culturally grounded worksheet can structure scientific reasoning while connecting school science with local knowledge in South Papua.

METHOD

This study employed a quantitative pre-experimental research design using a one-group pre-test-post-test design. The design was used to describe changes in students' critical thinking performance before and after implementation of the Sagu Sep ethnoscience-based science worksheet. The design is presented in Figure 1.

$$O_1 \quad X \quad O_2 \tag{1}$$

Where:
O_1 = Pre-test measurement before the intervention
X = Learning intervention using the Sagu Sep ethnoscience-based science worksheet
O_2 = Post-test measurement after the intervention

The study was conducted at SD Negeri 2 Merauke, South Papua, Indonesia, and involved 20 fifth-grade elementary school students. The participants were the intact fifth-grade class available at the research site. The study context was selected because the intervention was designed to connect elementary science learning with local cultural knowledge relevant to the South Papuan context.

The intervention used a Sagu Sep ethnoscience-based science worksheet that connected the local practice of Sagu Sep with science learning activities. Sagu Sep was treated as a contextual scientific phenomenon rather than as supplementary cultural information. The worksheet guided students through observation, problem identification, evidence-based reasoning, data collection and representation, logical interpretation, and evaluation.

Students' critical thinking skills were measured using a structured science learning test administered before and after the intervention. The assessment was organized around five indicators: (1) formulating problems based on a given phenomenon; (2) constructing arguments based on experimental evidence; (3) collecting and representing data through tables or graphs and relating the data to a hypothesis; (4) making logical interpretations or deductions based on experimental data; and (5) evaluating information based on facts, principles, or predetermined criteria. The same assessment framework was applied to the pre-test and post-test.

The research procedure followed three sequential stages. First, students completed the pre-test (O_1) to describe their initial critical-thinking performance. Second, students participated in science learning activities using the Sagu Sep ethnoscience-based worksheet (X). During the intervention, students engaged with Sagu Sep-related phenomena and completed activities involving problem

formulation, examination of evidence, data collection and representation, interpretation, and evaluation. Third, students completed the post-test (O_2) using the same assessment framework.

The data were analyzed using descriptive percentage analysis and group normalized gain (N-Gain). The percentage of achievement for each critical-thinking indicator was calculated as:

$$P = \frac{f}{N} X100\% \quad (2)$$

where P represents the percentage of achievement, f represents the frequency of students achieving the assessed criterion, and N represents the total number of students.

Improvement was analyzed using group N-Gain calculated from the group mean pre-test and post-test scores:

$$< \mathbf{g} >= \frac{\boldsymbol{Spost - Spre}}{\boldsymbol{Smax - Spre}} \quad (3)$$

Where S_{post} represents the group mean post-test score, S_{pre} represents the group mean pre-test score, and S_{max} represents the maximum possible score. The N-Gain categories were high ($g \geq 0.70$), medium ($0.30 \leq g < 0.70$), and low ($g < 0.30$).

Table 1. N-Gain interpretation criteria

N-Gain score	Category
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Medium
$g < 0.30$	Low

The N-Gain analysis was conducted at the group level rather than by calculating N-Gain for individual students. The analysis was performed for each critical-thinking indicator and for the overall critical-thinking score. This approach describes the magnitude of change in the participating group and does not provide an inferential test of statistical significance.

The research activities were coordinated with the school to ensure that implementation was consistent with classroom conditions and did not disrupt regular learning. Student identities and research data were treated confidentially and used solely for research and academic purposes. No personally identifying student information is reported in this article.

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RESULTS AND DISCUSSION

The results indicate a clear increase in the group-level critical-thinking scores after the implementation of the Sagu Sep ethnoscience-based science worksheet. The overall group mean increased from 0.00% on the pre-test to 89.23% on the post-test, resulting in a group N-Gain of 0.89, categorized as high. The five indicators also reached the high category, with N-Gain values between 0.85 and 1.00. Because the study used a one-group pre-test-post-test design, these values should be interpreted as evidence of substantial improvement within the participating group rather than as proof that the worksheet was superior to another learning approach. The pattern is nevertheless consistent with recent evidence that ethnoscience and local-wisdom-based learning can create contextual conditions that support higher-order thinking in science (Adawiah et al., 2026; Atmojo et al., 2025; Rhamadani et al., 2026)

Table 2. Changes in Students' Critical Thinking Performance

Critical Thinking Indicator	Pre-test (%)	Post-test (%)	Group N-Gain	Category
Formulating problems	0.00	100.00	1.00	High
Constructing arguments based on evidence	0.00	92.31	0.92	High
Collecting and representing data	0.00	84.62	0.85	High
Making logical interpretations	0.00	84.62	0.85	High
Evaluating information based on facts/principles	0.00	84.62	0.85	High
Overall	0.00	89.23	0.89	High

Note: N-Gain values were calculated from the group mean pre-test and post-test scores; no individual-student N-Gain was calculated.

The overall N-Gain score of 0.89 indicates a high level of improvement in students' critical thinking skills following the implementation of the instructional intervention. This finding is consistent with previous studies investigating ethnoscience-based instructional materials. A high N-Gain score of 0.88 was reported following the integration of ethnoscience into project-based learning materials (Hanum et al., 2023). Improvements in critical thinking skills were also reported through the implementation of a contextual science e-module integrating local wisdom (Hidayat et al., 2024). Similarly, a high N-Gain score for critical thinking was reported following the implementation of a local-wisdom-based science e-module at the elementary school level (Wahyudi et al., 2025). The potential of culturally contextualized worksheets to support the development of critical thinking and scientific literacy has also been demonstrated in previous studies (Indra et al., 2026; Purnawati et al., 2026). However, these studies involved different samples, instructional materials, and research designs; therefore, their numerical results should not be interpreted as directly comparable benchmarks. Instead, the convergence of these findings suggests that structured instructional materials can provide meaningful opportunities to connect local cultural phenomena with scientific reasoning.

The highest-performing indicator was formulating problems, which increased from 0.00% in the pre-test to 100.00% in the post-test, yielding an N-Gain score of 1.00. This result suggests that, following the learning intervention, students were able to formulate scientific problems based on the phenomena presented in the worksheet. One possible explanation for this improvement is the concrete and culturally meaningful nature of Sagu Sep, which allowed students to engage with a familiar cultural practice that could be observed, described, and questioned before developing formal scientific explanations. The Sagu Sep-making process involves observable scientific phenomena, particularly those related to heat transfer, providing opportunities to connect students' everyday experiences with scientific concepts (Supriyadi et al., 2020). Furthermore, ethnoscientific knowledge embedded in the traditional practices of South Papuan communities provides a relevant context for connecting local cultural experiences with school science (Rapsanjani et al., 2024). These characteristics may provide an authentic starting point for identifying scientific problems. This interpretation is consistent with previous studies highlighting the role of contextual learning based on local wisdom in engaging students with meaningful problems and supporting critical thinking development (Azura et al., 2023; Juhariyani & Atmojo, 2025).

The ability to construct evidence-based arguments increased from 0.00% in the pre-test to 92.31% in the post-test, yielding an N-Gain score of 0.92. This indicator reflects students' ability to connect observed or collected evidence with logical explanations rather than provide unsupported answers. The worksheet activities provided opportunities for students to observe the Sagu Sep-making process, examine relevant information, and use evidence to formulate reasoned responses. This finding is consistent with previous research demonstrating that the integration of ethnoscience and STEM learning can support the development of critical thinking and cultural literacy (Atmojo et al., 2025). Similarly, ethnoscience-based project learning materials have been associated with learning activities that emphasize the construction of knowledge through empirical evidence (Hanum et al., 2023). The finding also aligns with research indicating that STEM learning integrated with ethnoscience can improve elementary school students' critical thinking skills (Yuhendri et al., 2026). Taken together, these findings suggest that culturally relevant learning contexts, when combined with explicit

instructional prompts that require students to support their explanations with evidence, can provide meaningful opportunities to develop evidence-based reasoning.

The ability to collect and represent data increased from 0.00% in the pre-test to 84.62% in the post-test, yielding an N-Gain score of 0.85. This indicator represents an important link between observation and scientific reasoning because students need to organize their observations into tables, graphs, or other systematic representations before interpreting the results. This finding is consistent with research suggesting that ethnoscience-based learning can support the development of science process skills when cultural practices are transformed into structured scientific investigations (Adawiah et al., 2026). Scientific concepts embedded in local cultural practices, including measurement, biodiversity, heat transfer, waves, and sound, can also provide relevant contexts for school-based scientific investigations (Kasi et al., 2024). Furthermore, a guided inquiry module based on local wisdom has been reported to facilitate data collection and other science process skills among elementary school students (Rahmawati et al., 2026). Problem-based learning materials incorporating local wisdom have likewise demonstrated potential for engaging students in investigating scientific problems and working with evidence (Wati, 2025). Taken together, these findings suggest that integrating local cultural practices into structured learning activities can create opportunities for students to develop their ability to collect, organize, and represent scientific data.

The ability to make logical interpretations increased from 0.00% in the pre-test to 84.62% in the post-test, yielding an N-Gain score of 0.85. Logical interpretation requires students to establish relationships between evidence and explanations and to draw conclusions that are consistent with the available information. In this study, the worksheet activities guided students from observing a concrete cultural phenomenon to examining evidence and interpreting their findings. This learning progression is consistent with the view that local knowledge can enrich school science when observable cultural practices are systematically connected to scientific concepts (Kasi et al., 2024). Similarly, science learning materials based on local wisdom have been reported to support the development of students' critical thinking skills (Wahyuni et al., 2025). Local-wisdom-based science e-modules have also demonstrated potential for supporting scientific literacy and critical thinking (Mahfud & Indana, 2026). These findings highlight the importance of designing instructional materials based on local wisdom as structured sequences of reasoning tasks that guide students from observation and evidence examination to interpretation and conclusion, rather than presenting cultural knowledge merely as descriptive content.

The evaluation indicator increased from 0.00% in the pretest to 84.62% in the posttest, yielding an N-Gain score of 0.85. Evaluation requires students to assess information, arguments, or conclusions against relevant evidence, scientific principles, or established criteria. The observed improvement suggests that students became better able to evaluate information after participating in the learning activities. This skill is essential because critical thinking extends beyond identifying problems and interpreting evidence to determining whether claims and conclusions are adequately supported. The importance of explicitly measuring critical-thinking constructs in local-wisdom-based science learning has been emphasized in previous research (Dini & Kuswanto, 2025). The systematic assessment of critical-thinking skills has also been highlighted in science learning contexts that incorporate local wisdom (Cahayu et al., 2024). Furthermore, an ethnoscience-based e-worksheet has been developed to support the systematic development of critical-thinking skills (Shafnahriyah & Sukarmin, 2026). These studies provide a rationale for incorporating evaluation as an explicit learning objective and assessment indicator in the present worksheet.

The identical N-Gain scores for data collection and representation, logical interpretation, and evaluation (0.85) suggest that improvements occurred across several interconnected dimensions of scientific reasoning. Students were guided through a sequence of learning activities involving the observation of a phenomenon, the collection and organization of evidence, the interpretation of information, and the evaluation of findings. This progression reflects the potential of ethnoscience to connect students' cultural experiences with formal scientific inquiry rather than treating local culture merely as supplementary content. Previous research has indicated that ethnoscience-based learning grounded in local wisdom can support critical thinking while strengthening students' appreciation of local knowledge (MUH, 2024). The integration of ethnoscience into contextual teaching and learning has also been identified as a relevant approach to developing critical-thinking skills in elementary

science education (Juhariyani & Atmojo, 2025). In the present study, the alignment between the worksheet activities and the targeted critical-thinking indicators provides a plausible explanation for the observed improvements across multiple dimensions of reasoning.

These findings further highlight the pedagogical role of worksheets as structured learning resources that guide students through successive stages of scientific reasoning. By incorporating questions, observations, evidence collection, data representation, interpretation, and evaluation, a worksheet can make the reasoning process more explicit and manageable for elementary school students. The potential of culturally contextualized learning activities has been demonstrated through the development of an Ethno-STEAM-based worksheet (Purnawati et al., 2026). Digital ethnoscience-based worksheets have also been developed to support scientific literacy and critical thinking (Indra et al., 2026). Similarly, local wisdom has been incorporated into problem-based multimedia to provide contextual opportunities for developing critical-thinking skills (Pratiwi et al., 2024). A review of local-wisdom-based digital media has further highlighted the potential of contextual learning resources while indicating that their educational outcomes may vary according to the medium and instructional design (Aliyah et al., 2026). Accordingly, the contribution of the present worksheet lies not merely in its use of Sagu Sep as a cultural theme, but in its systematic use of this traditional practice as a context for engaging students in explicit scientific reasoning tasks.

The contribution of this study is further supported by the scientific phenomena associated with Sagu Sep preparation. Previous research identified heat-transfer concepts in the Sagu Sep-making process and proposed this traditional practice as a contextual medium for science learning (Supriyadi et al., 2020). Building on this foundation, the present study focuses on integrating Sagu Sep into a structured science worksheet and examining changes across several critical-thinking indicators. Within this instructional framework, Sagu Sep serves as a source of observable scientific phenomena through which students can formulate problems, construct evidence-based arguments, collect and represent data, interpret findings, and evaluate information. This approach is consistent with the view that integrating local culture into science education requires transforming cultural knowledge and practices into meaningful opportunities for scientific investigation (Kasi et al., 2024). Thus, the study extends the pedagogical application of Sagu Sep by positioning it as an organizing context for a sequence of critical-thinking activities in elementary science learning.

These findings are particularly relevant to science education in South Papua, where local knowledge can provide culturally meaningful contexts for learning. The relevance of ethnoscience in connecting local knowledge with school science has been highlighted in research conducted in South Papua (Rapsanjani et al., 2023). Similarly, the scientific concepts embedded in the Sagu Sep-making process demonstrate its potential as a contextual resource for science learning (Supriyadi et al., 2020). Integrating local knowledge into science education requires its accurate and respectful representation, ensuring that cultural practices are treated as meaningful sources of knowledge rather than merely as decorative learning themes. In this regard, the present study provides a classroom-based example of how a local cultural practice can be incorporated into a structured worksheet to engage students in specific scientific reasoning tasks

Several limitations need to be considered. The study involved only 20 fifth-grade students from one elementary school and used a one-group pretest-posttest design without a comparison group. In addition, the analysis was descriptive and based on group-level N-Gain; no inferential test was conducted. Therefore, the findings do not establish statistical significance, causal superiority over other approaches, or generalizability to other schools. Direct comparison of N-Gain values with previous studies should also be avoided because the studies differ in participants, instruments, learning models, and research designs. Future research should involve larger samples, multiple schools, validated and reliability-tested instruments, and comparison or control groups. Further studies could examine whether the Sagu Sep worksheet also supports scientific literacy, science process skills, cultural literacy, problem solving, and mathematical communication.

Overall, the recorded group mean increased from 0.00% to 89.23%, with an overall group N-Gain of 0.89. The five indicators had N-Gain values of 1.00 for problem formulation, 0.92 for evidence-based argumentation, and 0.85 for data collection and representation, logical interpretation, and evaluation. These descriptive findings suggest that a Sagu Sep ethnoscience-based worksheet can provide a context for structuring critical-thinking activities. Further studies

with documented and tested instruments, larger samples, and comparison groups are needed to determine whether similar patterns occur in other settings.

CONCLUSION AND SUGGESTION

The Sagu Sep ethnoscience-based science worksheet was followed by an increase in the critical-thinking performance of the 20 fifth-grade students participating in the study. The overall group N-Gain was 0.89 (high), with high N-Gain values across all five indicators: formulating problems (1.00), constructing evidence-based arguments (0.92), collecting and representing data (0.85), making logical interpretations (0.85), and evaluating information based on facts or principles (0.85). These findings suggest that Sagu Sep can provide a meaningful local context for structuring critical-thinking activities in elementary science learning.

Because the study used one school, a small sample, and no comparison group, future research should involve larger and more diverse samples, validated and reliability-tested instruments, and comparison or control groups. Further development can examine digital versions of the worksheet and other South Papuan cultural contexts, as well as related outcomes such as scientific literacy, science process skills, cultural literacy, problem solving, and mathematical communication.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Hafsemi Rapsanjani conceptualized the study, designed the research methodology, conducted the investigation, analyzed the data, and prepared the original manuscript. Wa Ode Siti Hamsina Day contributed to the development of the research framework, reviewed and critically revised the manuscript, and provided academic input. Both authors reviewed and approved the final version of the manuscript and agreed to be accountable for the work.

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DECLARATION OF GENERATIVE AI SOURCES

Generative artificial intelligence (AI) tools were used to assist with language editing, grammar refinement, and improving the clarity and academic presentation of the manuscript. The authors reviewed and revised all AI-assisted text, verified the accuracy of the scientific content and references, and take full responsibility for the integrity and final content of the manuscript. Generative AI tools were not credited as authors and did not replace the authors' responsibility for the research design, data collection, data analysis, interpretation of findings, or conclusions.

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