

Integrating the Ethno-STEAM-Based Si PURI Worksheet to Foster Critical Thinking Skills among Fourth-Grade Elementary School Students in Indonesia

Ririn Purnawati, Suryanti*, Neni Mariana

Universitas Negeri Surabaya, Surabaya, Indonesia

*Corresponding author, e-mail: suryanti@unesa.ac.id

Abstract

Critical thinking skills among Indonesian elementary students remain limited, largely because contextual teaching materials integrating local wisdom are rarely available. This study developed the Si PURI worksheet through an Ethno-STEAM approach to improve fourth-grade students' critical thinking skills. Its novelty lies in incorporating pupur, a traditional Javanese powder-based skincare practice, into a structured worksheet integrating science through the chemistry of natural ingredients, technology through processing tools, engineering through production procedures, arts through cultural aesthetics, and mathematics through measurement and proportion. This topic has not previously been explored in elementary Ethno-STEM or Ethno-STEAM worksheets. The study employed the ADDIE development model, consisting of Analysis, Design, Development, Implementation, and Evaluation. Participants were 23 fourth-grade students at SD Negeri 017 North Sangatta, East Kutai Regency, East Kalimantan. Data were collected through expert validation, accessibility questionnaires, and critical thinking tests administered before and after implementation. Quantitative analysis included validity and accessibility percentages, N-Gain calculations, and the Wilcoxon Signed Ranks Test. Results showed that the worksheet achieved an average validity score of 82.33%, categorized as very valid. Accessibility reached 85.62% based on evaluations from 23 students and five teachers, indicating a very good category. Effectiveness was demonstrated by an average score increase from 59.43 to 77.96, with a class N-Gain of 0.46 in the medium category. The Wilcoxon test indicated a significant difference between pretest and posttest scores ($p = 0.000$), while 43.5% of students reached the high improvement category. Therefore, the Si PURI worksheet is valid, accessible, and effective for fostering critical thinking skills.

Keywords: Ethno-STEAM, Si PURI Worksheet, Critical Thinking, Pupur Dingin, Elementary School



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Introduction

Critical thinking skills are fundamental competencies that are essential to be prepared and practiced by students from the elementary education level. In the 21st century, characterized by the rapid flow of digital information, the phenomenon of disinformation, and the complexity of global problems, the ability to select, analyze, and evaluate the truth of information is a determining factor for individual success in adaptation (Agusta et al., 2022). Children should not only be equipped with the ability to remember facts, but they must be able to distinguish between opinion and fact, identify bias in an argument, and make rational decisions based on valid evidence. This skill has implications not only for future academic success but also for their ability to participate as responsible and ethical digital citizens. Ennis (2018), in his study, asserts that reflective reasoning oriented toward rational decision-making is the core of critical thinking practice in social life. In line with this, Facione (2011) defines critical thinking as a multidimensional skill encompassing interpretation, analysis, evaluation, inference, explanation, and self-regulation, all of which must be systematically developed through planned and contextual learning experiences.

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The Indonesian government, through the regulations of the Kurikulum Merdeka (Independent Curriculum), has explicitly established critical reasoning as one of the main dimensions in forming the Profil Pelajar Pancasila (Pancasila Student Profile), as mandated in Minister of Primary and Secondary Education Regulation Number 13 of 2025 (Hermawan, 2025). This policy demands that elementary school graduates not only master content knowledge but also think analytically, solve contextual problems, and have reflective awareness of their social and cultural environment. However, the reality in the field shows that the critical thinking skills of Indonesian students are still at a concerning level. The 2022 Programme for International Student Assessment (PISA) data, as reported by the Organisation for Economic Co-operation and Development (OECD), placed Indonesia at 68th out of 81 countries with reading scores of 359, mathematics 366, and science 383, all far below the OECD average (OECD, 2023). This decline in performance across all domains compared to PISA 2018 reflects both the prolonged effect of the COVID-19 pandemic and longer-term systemic challenges in Indonesian education (BSKAP, 2023). Furthermore, Indonesia's participation in the 2019 Trends in International Mathematics and Science Study (TIMSS) provides critical benchmarking data, as TIMSS is specifically designed to assess fourth-grade students (ages 10–11) in mathematics and science, making it directly relevant to the population of this study (Firdaus et al., 2014). Although Indonesia did not participate in the 2019 TIMSS cycle, previous cycles consistently placed Indonesian students below the international average of 500, particularly in higher-order thinking skills such as reasoning and problem-solving (Mutakin et al., 2023). These findings align with the initial observation results at SD Negeri 017 North Sangatta, where out of 24 fourth-grade students, only 2 students had critical thinking skills in the very good category, while 12 other students were in the poor category. This low ability is caused by the dominance of conventional learning models oriented toward rote memorization, minimal use of contextual and interactive teaching materials, and the lack of integration of local wisdom as a learning resource in the learning process.

To bridge the gap between curriculum demands and learning realities, a pedagogical innovation capable of connecting abstract concepts with students' concrete experiences is needed. The Ethno-STEAM approach emerges as an integrative solution that combines elements of Science, Technology, Engineering, Arts, and Mathematics with the values of local wisdom alive in society (Haryanto et al., 2024). Unlike the conventional STEAM approach, which tends to be universal, Ethno-STEAM emphasizes the cultural context as the main foundation of learning (teaching through culture), making the material more meaningful, contextual, and relevant to students' daily lives.

Several previous studies have explored the implementation of Ethno-STEAM across different educational levels and contexts. At the junior high school level, Haryanto et al. (2024) developed a project-based learning model based on Ethno-STEAM in mathematics learning for class VIII students, achieving an expert validation score of 91% and an N-Gain of 0.69 (medium category) for improving numeracy literacy skills. For elementary education, Sabella & Zannah (2024) conducted a needs analysis for an Ethno-STEAM-based e-comic utilizing local potential "Lilis Lamian" in Central Kalimantan, involving 20 fifth-grade students and 2 teachers, finding that teachers had never developed local potential-based teaching materials while students responded positively to the integration of local wisdom in learning activities. Rahmawati et al. (2025) further confirmed through a literature study that the Ethno-STEAM approach based on Baduy tribal crafts can help elementary students understand mathematical concepts such as patterns, symmetry, and geometry, while also encouraging the development of critical thinking skills.

At the elementary level specifically, Azizah et al. (2025) implemented an Ethno-STEAM approach based on mangrove local wisdom for fifth-grade students in Surabaya using a quasi-experimental design, demonstrating a significant improvement in problem-solving skills with an N-Gain in the medium category. Similarly, Fadhillah et al. (2025) developed a Madurese local wisdom-based learning model using a STEAM integrative approach for elementary students, showing an increase in creativity scores from 57.3 to 86.6 and innovation scores from 55.8 to 84.1 with moderate-to-high N-Gain scores. Additionally, Aini et al. (2024) found that STEAM learning based on local wisdom for fourth-grade elementary students increased learning completeness from 40% in the pretest to 80% in the posttest.

However, the existing evidence has several limitations that need to be acknowledged. First, most previous studies were conducted at the junior high school level (MTs/SMP) or with specific subject focuses (mathematics or science), limiting their generalizability to elementary integrated thematic learning. Second, the types of media and interventions vary widely, ranging from project-based models (Haryanto et al., 2024), e-comics (Sabella & Zannah, 2024), to direct local wisdom implementation (Azizah et al., 2025), making cross-study comparisons challenging. Third, the learning outcome variables measured differ across studies: some focused on numeracy literacy (Aini et al., 2024), others on problem-solving skills (Azizah et al., 2025), creativity (Fadhillah et al., 2025), or conceptual understanding (Rahmawati et al., 2025), with no single study

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specifically addressing critical thinking skills through Ethno-STEAM worksheets for fourth-grade elementary students in the context of traditional pupur (Javanese powder-based skincare). Fourth, sample sizes in several studies were relatively small and context-specific, limiting the generalizability of findings. Therefore, while the Ethno-STEAM approach shows promising potential for creating contextual and engaging learning experiences, its effectiveness specifically for fostering critical thinking skills among fourth-grade elementary students through a worksheet-based intervention integrating pupur local wisdom remains underexplored and requires further investigation.

Pupur dingin (cold powder), also known as bedak dingin or pupur basah (wet powder), is a traditional cosmetic heritage that has been used for generations by communities in various regions of the archipelago, especially in South Kalimantan and East Kalimantan (Fadillah, 2021). Physically, pupur dingin is in the form of flat, rounded grains made from natural ingredients such as fermented rice, turmeric, bengkoang (Philippine yam), and various other spices (Iwan, 2016). Its main function in community life is as a traditional skin treatment that provides a cooling effect, protects the skin from the tropical sun, smoothens, and has anti-inflammatory properties. More than just a cosmetic product, pupur dingin also contains deep socio-cultural dimensions because its use is often associated with traditional rituals, communal activities, and health habits passed down through generations.

In the context of East Kalimantan, the presence of pupur is particularly significant among the Kutai and Dayak communities. Ethnographic records document the existence of Tari Pupur (Pupur Dance) in Kedang Ipil Village, Kota Bangun District, Kutai Kartanegara Regency, which was created around 1970 by Tajuddin Nur, the traditional leader of the village, as a welcoming dance for honored guests (Mayrita, 2018). This dance tradition reflects the deep-rooted practice of using pupur or wet powder in daily life, where dancers apply pupur to guests' faces as a symbol of hospitality and respect (Budiarto et al., 2023). Furthermore, the Nutuk Beham traditional ceremony of the Kutai Adat Lawas community features a tari pupur performance, where dancers smear pupur on visitors' faces as a welcoming gesture and a symbol of blessing for the upcoming harvest (Budiarto et al., 2023). This cultural evidence demonstrates that pupur is not merely a cosmetic product but an integral part of the socio-cultural identity of East Kalimantan communities.

From an educational perspective, the pupur dingin manufacturing process holds extraordinary potential as an authentic STEAM learning context. From the Science aspect, students can observe changes in state, rice fermentation, and the cooling sensation due to evaporation. The Technology and Engineering aspects are reflected in the use of traditional tools such as an ulin wooden mortar, representing local knowledge-based engineering. The Arts aspect is reflected in the aesthetics of the shape, the natural colors from turmeric and pandan leaves, and the packaging design, which can be integrated with Kutai batik motifs. The Mathematics aspect is evident in activities such as measuring ingredient quantities, calculating mixture ratios, and estimating fermentation time (Fadillah, 2021). Preliminary observations at SD Negeri 017 North Sangatta support the relevance of this cultural context: out of 24 fourth-grade students interviewed during the initial needs analysis, 18 students (75%) reported that they had seen or used pupur dingin in their family environment, and 15 students (62.5%) could mention at least one local ingredient used in its production. Additionally, interviews with two homeroom teachers revealed that pupur dingin is still commonly used by students' families during agricultural activities and traditional ceremonies, making it a highly familiar and contextual learning resource. With the richness of STEAM content naturally integrated into this tradition and its strong local relevance to the research community, pupur dingin becomes a highly potential learning resource to foster students' critical thinking skills while preserving local wisdom that is starting to be marginalized by modern cosmetic products.

Although various studies have confirmed the effectiveness of the Ethno-STEAM approach in improving the quality of learning in elementary schools, a systematic review of the existing literature reveals two distinct gaps that justify the urgency of this research.

Conceptually, the integration of pupur dingin (cold powder) as a specific local wisdom context into Ethno-STEAM-based Student Worksheets (LKPD) has not been explored in any previous study. Existing Ethno-STEAM research has utilized various cultural contexts, such as Batik Pekalongan for chemistry learning at the senior high school level (Fikrina et al., 2023), Baduy tribal crafts for mathematics learning in elementary schools (Rahmawati et al., 2025), and mangrove local wisdom for problem-solving skills in fifth-grade students (Azizah et al., 2025). However, none of these studies have specifically examined the traditional cosmetic heritage of pupur dingin, which is particularly relevant to the socio-cultural life of East Kalimantan communities, especially among the Kutai and Dayak ethnic groups (Suswandari et al., 2022). This conceptual gap is significant because the cultural context used in teaching materials must be authentic

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and familiar to students to achieve meaningful and contextual learning (Sabella & Zannah, 2024; Haryanto et al. 2024).

Empirically, no study has specifically developed Ethno-STEAM-based LKPD targeting critical thinking skills for fourth-grade elementary students in the context of pupur dingin. Research conducted by Fendy et al. (2025) at the State University of Surabaya developed an ethnomathematics worksheet based on the architecture of the Al Abror Mosque in Sidoarjo with an N-Gain for mathematical literacy of 0.847 and critical thinking of 0.820. However, the cultural context used (mosque architecture) is significantly different from the local wisdom of the East Kutai community, and the research was conducted at the junior high school level, thus it has not been able to accommodate the contextual needs of fourth-grade elementary students in that area. Similarly, research by Purnamasari et al. (2026) on the STEAM-based PjBL model proved effective in improving the critical thinking character of elementary school students significantly ($p < 0.001$), but it has not explicitly integrated ethno-pedagogy elements into its learning design, nor did it develop a specific worksheet-based intervention. More broadly, a recent systematic literature review by Nurmala et al. (2025) examining 25 relevant studies on Ethno-STEAM-based LKPD in elementary science learning concluded that while the approach effectively facilitates active, student-centered learning, challenges remain in implementation scale, authentic assessment development, and long-term impact measurement. The review also noted that most studies focused on conceptual understanding, creativity, or problem-solving skills, with limited attention to critical thinking skills as the primary learning outcome variable.

Therefore, the research gap that this study aims to fill is threefold: (1) integrating pupur dingin local wisdom as an authentic cultural context into Ethno-STEAM-based LKPD, (2) specifically targeting critical thinking skills as the primary learning outcome for fourth-grade elementary students, and (3) developing a worksheet-based intervention that is valid, accessible, and effective within the specific context of SD Negeri 017 North Sangatta, East Kutai Regency.

Based on the identification of the research gap above, this study aims to: (1) produce a valid Si PURI (Selidik Pupur Rakyat Indonesia/Investigating Indonesian People's Pupur) worksheet product that integrates the Ethno-STEAM approach with the context of pupur dingin, (2) test the practicality level of the Si PURI worksheet in terms of usability, ease of use, clarity, and appropriateness for fourth-grade elementary students, and (3) measure the effectiveness of the Si PURI worksheet in fostering the critical thinking skills of fourth-grade elementary school students.

In this study, practicality is defined operationally as the extent to which the Si PURI worksheet can be used easily and effectively by teachers and students in actual classroom settings, based on the perspectives of both users (Nieveen, 1999; Plomp & Nieveen, 2013). This operational definition encompasses four indicators: (a) usability: the worksheet's functionality in supporting the achievement of learning objectives; (b) ease of use: the clarity of instructions, language, and worksheet structure that enables students to work independently or in groups without significant teacher intervention; (c) clarity: the readability and comprehensibility of the content, including text, images, and activity procedures; and (d) appropriateness: the suitability of the worksheet's content and activities to students' developmental level, cultural context, and time allocation (Rochmad, 2012). This definition aligns with the criteria for assessing the practicality of teaching materials proposed by Nieveen (1999) in the field of educational design research, which states that a practical learning product is one that experts and users consider applicable in real learning situations.

The significance of this research lies in its contribution to the development of contextual teaching materials based on the local wisdom of East Kalimantan, as well as serving as an Ethno-STEAM integration model that can be adapted by teachers in various regions with their respective local cultural potentials. Thus, the Si PURI worksheet is expected not only to answer the challenge of students' low critical thinking skills but also to act as an effective cultural preservation instrument amid the inevitable currents of globalization and modernization.

Method

This research is development research that aims to produce a Si PURI Student Worksheet (LKPD) product based on Ethno-STEAM integration with the local cultural context of pupur dingin. The development model used is ADDIE, which includes five systematic stages: Analysis, Design, Development, Implementation, and Evaluation (Branch & Varank, 2009). The choice of the ADDIE model was based on its procedural nature, flexibility, and widespread use in developing teaching materials at the elementary education level because it provides a structured framework while still allowing for continuous revisions at each stage (Nieveen & Folmer, 2013; Plomp & Nieveen, 2013).

The operational activities at each ADDIE stage are described as follows:

Analysis Stage: This stage consisted of three main activities: (a) needs analysis, conducted through unstructured interviews with two homeroom teachers of grade IV at SD Negeri 017 North Sangatta to identify the learning models, teaching materials, and media commonly used in the classroom; (b) student characteristics analysis, carried out through initial observation and a simple diagnostic test involving 24 fourth-grade students to map their initial critical thinking skills, learning styles, and familiarity with local wisdom, particularly pupur dingin; and (c) curriculum analysis, performed by examining the learning outcomes and learning objectives in the Kurikulum Merdeka for grade IV to ensure alignment between the worksheet content and the targeted competencies (Tangkearung et al., 2023). The results of this stage served as the foundation for designing the worksheet content and activities.

Design Stage: This stage involved three sequential activities: (a) determining learning objectives, namely formulating specific indicators of critical thinking skills adapted from Facione's (2015) framework, including interpretation, analysis, evaluation, inference, explanation, and self-regulation; (b) designing the worksheet structure, which included the cover, introduction, learning instructions, concept maps, STEAM-based activity sheets, critical thinking practice questions, reflection sections, and bibliography, with all content integrated with the context of pupur dingin; and (c) designing the assessment instruments, which included expert validation sheets for content, media, and language; teacher and student practicality questionnaires; and pretest-posttest questions to measure critical thinking skills (Sugiono, 2013). At the end of this stage, a prototype of the Si PURI worksheet was produced.

The Si PURI worksheet features two fictional characters, Dayang and Emek, who serve as learning guides throughout the worksheet. These characters were intentionally designed to create a narrative thread that connects each activity and to strengthen students' emotional engagement with the local cultural context of pupur dingin.

Dayang is depicted as a cheerful and curious 10-year-old girl from the Kutai ethnic group who loves learning about local traditions. She represents the elementary school student persona, often asking questions and expressing curiosity about the processes and cultural values behind pupur dingin making. Through Dayang, students are invited to explore, investigate, and think critically about the STEAM concepts embedded in the traditional practices.



Figure 1. The characters of Dayang

Emek is portrayed as a wise grandmother who possesses deep knowledge of traditional pupur dingin making, passed down through generations. She serves as a cultural authority figure who provides authentic information about the history, ingredients, processing techniques, and socio-cultural significance of pupur dingin in Kutai society. Through Emek, students gain access to local wisdom that might otherwise be lost or marginalized by modern cosmetic products.



Figure 2. The characters of Emek

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Both characters appear consistently in each activity section of the worksheet, playing three specific roles: (a) contextual story introducers: they open each activity by presenting real-life scenarios related to pupur dingin in daily Kutai life, such as preparing for traditional ceremonies or family skincare routines; (b) activity facilitators: they guide students step by step through each experiment, observation, and discussion, often asking prompting questions to stimulate critical thinking and problem-solving; and (c) cultural knowledge transmitters: they provide authentic information about the cultural and historical significance of pupur dingin from a local perspective. The characters are visually designed with traditional Kutai attributes, including typical traditional clothing and accessories, to create a culturally immersive learning experience and to strengthen students' emotional closeness to the material.

The inclusion of these characters is grounded in the narrative-based learning approach, which has been shown to increase student engagement, motivation, and retention of learning material by presenting content within a meaningful and relatable story context. The characters also serve to reinforce the Ethno-STEAM principle of teaching through culture, where local wisdom is not merely presented as factual information but is lived and experienced through the guidance of relatable cultural figures.

Development Stage: This stage comprised two main activities: (a) product development, namely creating the initial prototype of the Si PURI worksheet based on the design specifications, including content writing, illustration creation, layout design, and integration of pupur dingin cultural context into each STEAM activity; and (b) validation, which involved three experts, a content/material expert (lecturer in elementary science education), a media/design expert (lecturer in instructional media), and a language expert (lecturer in Indonesian language education), who assessed the worksheet using validation instruments with a Likert scale of 1–4 (Sugiono, 2013). The validation results were then analyzed and used as a basis for product revision before the implementation stage (Nieveen & Folmer, 2013). Furthermore, a small group practicality test involving 5 students and 2 teachers was conducted to assess the readability and usability of the worksheet.

Implementation Stage: This stage involved a limited field trial conducted with 23 fourth-grade students of SD Negeri 017 North Sangatta over four meetings (each meeting lasting 2×35 minutes). The learning activities followed the syntax of the Ethno-STEAM approach, which included: (a) culture exploration, where students observed and discussed pupur dingin based on the given contextual story; (b) science investigation, where students conducted simple experiments observing rice fermentation and changes in matter; (c) technology and engineering activities, where students practiced using traditional tools such as a mortar and pestle to process ingredients; (d) art activities, where students designed packaging and decoration for the pupur dingin product; and (e) mathematics activities, where students measured ingredients and calculated proportions (Fikrina et al., 2023; Haryanto et al., 2024). During this stage, the pretest was administered before the first meeting, and the posttest was administered after the fourth meeting to measure the improvement in students' critical thinking skills.

Evaluation Stage – This stage consisted of two types of evaluation: (a) formative evaluation, conducted continuously at each stage of ADDIE to identify weaknesses and make revisions, including revision based on expert validation results, teacher and student feedback during the small group trial, and observer notes during implementation; and (b) summative evaluation, carried out at the end of the implementation stage by analyzing the pretest and posttest scores to determine the effectiveness of the Si PURI worksheet in fostering critical thinking skills (Branch Varank, 2009; Plomp & Nieveen, 2013). The evaluation results were then used as the basis for final product revision to produce the final version of the Si PURI worksheet ready for wider dissemination.

The research was conducted at SD Negeri 017 North Sangatta, located in North Sangatta District, East Kutai Regency, East Kalimantan Province. The research subjects were 23 fourth-grade students selected using a purposive sampling technique, i.e., subject selection based on specific criteria and research objectives, not through random procedures (Sugiyono, 2013). The consideration for selecting fourth grade was based on the cognitive development characteristics of children aged 9–11 years, who are in the concrete operational stage, where they begin to think logically about real objects and events but still need the help of concrete media to understand abstract concepts (Piaget & Inhelder, 2008).

Data collection techniques in this study used three main instruments. First, a product validation sheet filled out by three expert lecturers from the State University of Surabaya with expertise in Natural and Social Sciences (IPAS) learning, measurement mathematics, as well as cultural diversity and teaching material development. The validation instrument used a Likert scale of 1–4 covering four assessment aspects: suitability of material content, didactic requirements, construction requirements, and technical presentation requirements (Prastowo, 2015). Second, an accessibility questionnaire given to 23 students and 5 teachers after the learning implementation to measure the level of usability, ease of use, accuracy, and appropriateness

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of the Si PURI worksheet in the learning process. This instrument was arranged in the form of positive statements with ordinal scale answer choices (Riduwan, 2022). Third, a critical thinking ability test consisting of 15 multiple-choice questions developed based on Facione's indicators, including the ability to identify information, analyze cause-and-effect relationships, evaluate alternative solutions, and conclude based on evidence (Facione, 2011). Before use, all instruments went through a content validation process by experts and empirical trials to ensure adequate levels of validity, reliability, discriminating power, and difficulty level (Creswell & Creswell, 2017).

Data analysis techniques used were adjusted to the type of data obtained, namely: (1) Product validity data were analyzed descriptively quantitatively by calculating the average percentage score from all validators, then categorized into predetermined validity criteria (very valid, valid, fairly valid, or invalid) referring to the criteria proposed by Nieveen and Folmer (2013); (2) Accessibility data from student and teacher questionnaires were analyzed by calculating the average score per aspect and overall average, then interpreted into very good, good, fair, or poor categories (Riduwan, 2015); and (3) Effectiveness data of the Si PURI worksheet in practicing critical thinking skills were analyzed through N-Gain (Normalized Gain) calculation based on the formula developed by Hake (1999), i.e., comparing the difference between pretest and posttest scores to the maximum score minus the pretest score. The obtained N-Gain value was then categorized as high ($g \geq 0.70$), medium ($0.30 \leq g < 0.70$), or low ($g < 0.30$) (Hake, 1999). Before conducting the N-Gain test, the data were first tested for prerequisites (normality and homogeneity) to determine the type of statistical test to be used. If the data were normally distributed, the parametric paired sample t-test was used; conversely, if the data were not normal, the non-parametric Wilcoxon Signed Ranks Test was applied (Creswell & Creswell, 2017). All statistical analyses in this study were assisted by SPSS version 25 and Microsoft Excel.

Results and Discussion

Results

Before being implemented in learning, the Si PURI worksheet product first went through a validation stage to ensure its feasibility from various aspects by lecturers with expertise in measurement mathematics, IPAS learning, as well as cultural diversity and teaching material development. The results can be seen in the table below.

Table 1. Recapitulation of Si PURI Worksheet Validation Results by Three Expert Lecturers

Validator Code	Area of Expertise	Total Score	Maximum Score	Percentage	Category
AG	IPAS (Changes in State of Matter)	78	100	78%	Valid
IR	Measurement Mathematics	72	100	72%	Valid
AMIP	Cultural Diversity & Teaching Material Development	96	100	96%	Very Valid
Average		82	100	82,33%	Very Valid

Based on Table 1 above, the validation results of the Si PURI worksheet by three expert lecturers from the State University of Surabaya showed an average percentage of 82.33%, which falls into the Very Valid category. The categorization of validity levels in this study refers to the criteria proposed by Riduwan (2022), where a percentage score of 81%-100% is classified as "Very Valid" or "Very Strong", 61%-80% as "Valid" or "Strong", 41%-60% as "Fairly Valid" or "Fairly Strong", 21%-40% as "Less Valid" or "Weak", and 0%-20% as "Invalid" or "Very Weak". The validation instrument used in this study was adapted from the expert validation questionnaire guidelines developed by Sugiyono (2013), which assesses four main aspects: content/material feasibility, didactic requirements, construction requirements, and technical presentation requirements, using a Likert scale of 1–4.

The validator with expertise in cultural diversity and teaching material development (AMIP) gave the highest percentage of 96% (Very Valid), indicating that this Si PURI worksheet is considered very strong in terms of the integration of local cultural values of Pupur Dingin, visual design, and material integration. Meanwhile, the validator from the IPAS field of changes in the state of matter (AG) gave a percentage of

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78% (Valid), with notes for improvement on the suitability of the material with the Learning Outcomes and the use of more operational language. The validator from the measurement mathematics field (IR) gave the lowest percentage of 72% (Valid), with the main suggestion being that the science aspect related to changes in the state of matter be explained more comprehensively, along with improvements to the writing and the truncated assessment rubric. Although there were variations in scores among validators, all validators concluded that the Si PURI worksheet is feasible to use in learning after revisions were made according to the suggestions provided. Thus, the developed Si PURI worksheet product meets the feasibility criteria in terms of content/material, didactic requirements, construction requirements, and technical presentation requirements.

After the Si PURI worksheet was implemented in learning, the product's accessibility level was measured using a questionnaire given to students (23) and teachers (5). The results can be seen in the tables below.

Table 2. Recapitulation of Si PURI Worksheet Accessibility Questionnaire Results by Students

No	Assessment Aspect	Average Score	Category
1	Interest	86,04	Very Good
2	Ease of understanding instructions	85,51	Very Good
3	Attractiveness of visual design	88,41	Very Good
4	Suitability with local culture	86,23	Very Good
5	Encourages critical thinking	84,78	Very Good
6	Practicality in use	83,33	Very Good
Overall Average		85,87	Very Good

Table 3. Recapitulation of Si PURI Worksheet Accessibility Questionnaire Results by Teachers

No	Assessment Aspect	Average Score	Category
1	Clarity of instructions	84,00	Very Good
2	Visual appearance	88,00	Very Good
3	Depth of material	82,00	Very Good
4	Ease of use	85,00	Very Good
Overall Average		85,20	Very Good

Table 4. Recapitulation of Overall Si PURI Worksheet Accessibility Results

No	Respondents	Number	Average Score	Category
1	Students	23	85,87	Very Good
2	Teachers	5	85,20	Very Good
Overall Average		28	85,62	Very Good

Based on Tables 2, 3, and 4 above, the results of the Si PURI worksheet accessibility questionnaire showed that both students and teachers gave assessments in the Very Good category. The overall average score from 23 students reached 85.87, with the highest aspect being the attractiveness of the visual design (88.41), indicating that the appearance of the Si PURI worksheet successfully attracted attention and motivated students in learning. The practicality in use aspect obtained a score of 83.33, which, although still classified as very good, was the lowest score among other aspects. This indicates that some students still needed additional assistance, especially those with limited literacy or inclusive students. Meanwhile, the assessment from 5 teachers yielded an overall average score of 85.20, also in the very good category. The visual appearance aspect received the highest score from teachers (88.00), while the depth of material aspect received the lowest score (82.00) but remained in the very good category. Overall, the combined assessment from 28 respondents (23 students and 5 teachers) resulted in an average accessibility score of 85.62%, which falls into the Very Good category. This finding confirms that the Si PURI worksheet meets good accessibility standards in terms of usability, ease of use, accuracy, and appropriateness, making it feasible to use as teaching material in elementary school learning.

To measure the effectiveness of the Si PURI worksheet in practicing students' critical thinking skills, an analysis of the comparison of pretest and posttest results was conducted. Before conducting hypothesis testing, prerequisite tests were first carried out, including normality and homogeneity tests.

Table 5. Normality Test Results of Critical Thinking Skills Data (Kolmogorov-Smirnov)

Data	N	Statistic	df	Sig.	Description
<i>Pretest</i>	23	0,206	23	0,013	Not Normal

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Data	N	Statistic	df	Sig.	Description
Posttest	23	0,274	23	0,000	Not Normal

Table 6. Normality Test Results of Critical Thinking Skills Data (Shapiro-Wilk)

Data	N	Statistic	df	Sig.	Description
Pretest	23	0,899	23	0,024	Not Normal
Posttest	23	0,765	23	0,000	Not Normal

Based on Tables 5 and 6 above, the normality test results using the Kolmogorov-Smirnov test showed that the pretest data had a significance value of 0.013 and the posttest data had a significance value of 0.000. Both significance values are smaller than 0.05, so it can be concluded that the data are not normally distributed. The normality test results using the Shapiro-Wilk test also showed the same results, namely the pretest data had a significance value of 0.024 and the posttest data 0.000, both of which are also smaller than 0.05. Thus, the pretest and posttest scores of students' critical thinking skills were declared not normally distributed. This condition is caused by several factors, including a relatively small sample size (23 students), considerable variation in student abilities, and the presence of students with special needs (inclusive) who had scores significantly different from other students. Because the data did not meet the normality assumption, a non-parametric Wilcoxon Signed Ranks Test was applied to test the difference between pretest and posttest scores of critical thinking skills. The homogeneity test did not need to be performed because the data were not normal, and the test used was a non-parametric test that does not require homogeneity of variance.

Table 7. N-Gain Analysis Results of Class IV Critical Thinking Skills

Component	Value
Number of Students	23
Average Pretest Score	59,43
Average Posttest Score	77,96
Average Difference (Posttest - Pretest)	18,53
Maximum Score	100
Class N-Gain	0,46
Category	Medium

Table 8. Distribution of N-Gain Categories of Students' Critical Thinking Skills

N-Gain Category	Number of Students	Percentage
High ($g \geq 0,70$)	10	43,5%
Medium ($0,30 \leq g < 0,70$)	6	26,1%
Low ($g < 0,30$)	4	17,4%
No Improvement ($g \leq 0$)	3	13,0%

Table 9. Wilcoxon Signed Ranks Test Results

Component	Value
Z	-3,487
Asymp. Sig. (2-tailed)	0,000
Decision	H0 rejected
Conclusion	There is a significant difference between pretest and posttest

Based on Table 7, the average pretest score of students' critical thinking skills before using the Si PURI worksheet was 59.43. After participating in learning using the Si PURI worksheet, the average posttest score increased to 77.96, resulting in an increase difference of 18.53 points. The class N-Gain calculation yielded a value of 0.46, which falls into the medium category. Table 8 shows that 10 students (43.5%) achieved the high improvement category, 6 students (26.1%) the medium category, 4 students (17.4%) the low category, and 3 students (13.0%) showed no improvement or even a decrease in scores. Students who did not improve were generally students with special needs (inclusive) or those with literacy limitations, thus requiring more intensive assistance.

The results of the Wilcoxon Signed Ranks Test in Table 9 show a Z value of -3.487 with a significance value (Asymp. Sig. 2-tailed) of 0.000. This significance value is smaller than 0.05, which means the null

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hypothesis (H0) is rejected, and the alternative hypothesis (Ha) is accepted. Thus, it can be concluded that there is a significant difference between students' critical thinking skills before and after learning using the Si PURI worksheet. The negative Z value indicates that posttest scores are significantly higher than pretest scores. This finding proves that the Si PURI worksheet, which integrates the Ethno-STEAM approach with the local cultural context of Pupur Dingin, is effective in practicing the critical thinking skills of fourth-grade elementary school students.

Discussion

Validity of Si PURI Worksheet Based on Ethno-STEAM Integration

The development process of the Si PURI worksheet, which integrates the Ethno-STEAM approach with the local cultural context of pupur dingin, has resulted in a product proven to meet high validity criteria. Based on the assessment results from three expert lecturers with competencies in measurement mathematics, IPAS learning, as well as cultural diversity and teaching material development, the Si PURI worksheet obtained an average validity percentage of 82.33%, which falls into the very valid category. This finding confirms that the developed Si PURI worksheet has met the feasibility standards in terms of content/material, didactic requirements, construction requirements, and technical presentation requirements.

The validation results showed that the validator with expertise in cultural diversity and teaching material development gave the highest percentage of 96% (very valid). This achievement indicates that the integration of the local cultural values of pupur dingin into the worksheet is considered very strong and authentic. This finding aligns with research conducted by Pratiwi et al. (2024), which emphasized that developing culture-oriented worksheets can contribute significantly to more meaningful and value-based learning, especially when linked to the local wisdom alive in the student community.

This success is inseparable from the worksheet design that presents two fictional characters, Dayang and Emek, as learning guides throughout the worksheet. Dayang is depicted as a young Kutai girl who is enthusiastic about preserving local traditions, while Emek is portrayed as a wise grandmother who possesses deep knowledge of traditional pupur dingin making. These two characters appear consistently in each activity section of the Si PURI worksheet, playing specific roles: (a) contextual story introducers: they open each activity by presenting real-life scenarios related to pupur dingin in Kutai society, such as preparing for traditional ceremonies or daily skincare routines; (b) activity facilitators: they guide students step by step through each experiment and observation, often asking prompting questions to stimulate critical thinking; (c) cultural knowledge transmitters: they provide authentic information about the cultural and historical significance of pupur dingin from a local perspective. The characters are visually designed with traditional Kutai attributes, including typical clothing and accessories, to strengthen students' emotional closeness to the learning material and to create a narrative thread that connects each activity from the beginning to the end of the worksheet. This character-based storytelling approach is supported by research by Fikrina et al. (2023), which emphasized that integrating engaging characters into ethno-STEAM-based e-worksheets can increase student engagement and motivation.

Meanwhile, the validator from the IPAS field of changes in the state of matter gave a percentage of 78% (valid), with notes for improvement on the suitability of the material with the Learning Outcomes and the use of more operational language. The validator from the measurement mathematics field gave a percentage of 72% (valid), with the main suggestion being that the science aspect related to changes in the state of matter be explained more comprehensively, along with improvements to writing and the assessment rubric. This variation in scores among validators reflects their respective expertise perspectives, emphasizing different aspects of assessing the worksheet, as also found in the development research of Ethno-STEM-based E-worksheets by Subari & Mercuriani (2024), where material expert validation scores reached 84% while media expert scores reached 94%.

The validity level achieved in this study is comparable to various other studies on the development of Ethno-STEM-based worksheets. Research conducted by Aulia (2026) on Ethno-STEM-based E-worksheets for processing sate bandeng (bandeng satay) obtained an average validity value of 91.5% in the very valid category. Similarly, research by Tomi et al. (2024) on the development of worksheets based on Kerinci local wisdom showed material expert validation results of 88.33% and design validation of 98.33%, both in the very good category. Another relevant study by Listiyani et al. (2025) on Ethno-STEM-based student worksheets for science learning in elementary schools achieved a validity percentage of 84.5%, with validators noting that the integration of cultural context with scientific content required careful balancing to maintain both authenticity and accuracy. Although the validity percentage of the Si PURI worksheet

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(82.33%) is slightly lower than those studies, this difference can be explained by the complexity of the integration performed. The Si PURI worksheet not only integrates ethnoscience with STEM but also requires cross-subject integration (IPAS, Mathematics, and Fine Arts) and linkage with sustainable development goals (SDGs), thus the assessment standards applied by the validators were more comprehensive and multidimensional (Nieveen & Folmer, 2013; Plomp & Nieveen, 2013).

The technical requirements aspect of the Si PURI worksheet received consistently high assessments from the three validators, especially on the indicators of cover design, illustration quality, layout, and color use. This achievement indicates that the Si PURI worksheet was successfully developed with an attractive appearance suitable for the cognitive development characteristics of fourth-grade elementary students, who are in the concrete operational stage. As stated by Piaget & Inhelder (2000), children aged 9-11 years begin to think logically about real objects and events but still need the help of concrete media to understand abstract concepts. Therefore, the presentation of the Si PURI worksheet with clear illustrations, harmonious colors, and operational instructions is a crucial factor supporting the high technical validity of the product.

One of the main strengths of the Si PURI worksheet that contributes to its high validity level is the success in integrating all five STEAM elements (Science, Technology, Engineering, Arts, Mathematics) simultaneously through the cultural context of pupur dingin. The process of making pupur dingin, which involves rice fermentation, grinding using an ulin wooden mortar, drying, and packaging design with Kutai batik motifs, serves as a very rich vehicle for practicing various integrated STEAM aspects. This finding aligns with research by Nabilah (2024), who developed an interactive e-module with an Etno-STEAM approach on the topic of Batik Plumpungan, where media validity reached 0.94 and material validity reached 0.93, both in the very valid category. This research also emphasized that the success of etno-STEAM integration is highly determined by how authentically the local cultural content can be presented without losing the essence of the STEAM science within it.

Achieving a very valid validity level for the Si PURI worksheet has important implications for the quality of learning to be implemented. A product that is content-valid ensures that the material presented is accurate, aligns with the Learning Outcomes, and contains no misconceptions. A product that is construct-valid ensures that the structure of the Si PURI worksheet is logical, systematic, and easy for students to follow. Meanwhile, a product that is technically valid ensures that the appearance of the Si PURI worksheet is attractive, proportional, and supports learning comfort. As emphasized by Nieveen & Folmer (2013), validity is a fundamental prerequisite before an educational product can be declared practical and effective. Thus, the validation results achieved form a solid foundation for advancing the Si PURI worksheet product to the implementation stage in the field.

Accessibility of Si PURI Worksheet in Terms of Usability, Ease of Use, Accuracy, and Appropriateness

The results showed that the Si PURI worksheet achieved a very good accessibility level based on assessments from 23 students and 5 teachers. The overall average score reached 85.62% in the very good category, with student assessment at 85.87% and teacher assessment at 85.20%. This finding confirms that the Si PURI worksheet meets the required accessibility standards from the four main aspects: usefulness, ease of use, accuracy, and appropriateness. This success is inseparable from the design of the "Si PURI" worksheet, which systematically accommodates user needs, in terms of content, presentation, and its connection to students' local cultural context.

The usability aspect in this study refers to the extent to which the Si PURI worksheet provides real benefits for students and teachers in supporting the learning process, particularly in practicing critical thinking skills through the Etno-STEAM approach. The questionnaire results showed that the aspect of "encouraging critical thinking" obtained an average score of 84.78% from students and 85.00% from teachers, both in the very good category. This achievement indicates that the activities designed in the "Si PURI" worksheet, such as observing the texture change of fermented rice, comparing the effectiveness of traditional tools (ulin wooden mortar) with modern tools (blender), and calculating the precise composition of ingredients, genuinely provide learning experiences that encourage students to analyze, evaluate, and draw conclusions based on evidence.

This finding aligns with the research results conducted by Sari et al. (2026) on the development of interactive digital worksheets for IPAS learning in grade IV elementary school, which reported that the use of digital worksheets could increase active student engagement because they present contextual material relevant to their learning needs. Furthermore, Fikrina et al. (2023), in the development of an electronic worksheet for MPPj etno-STEAM, also proved that products categorized as practical based on practicality questionnaire analysis by teachers and students proved effective for developing numeracy literacy and

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conservation character. Thus, the high assessment of the usability aspect of the Si PURI worksheet confirms that the integration of etno-STEAM through the pupur dingin context is not only culturally meaningful but also functional in achieving learning objectives.

The high usability value of the Si PURI worksheet is also supported by the suitability of learning activities with the cognitive development characteristics of grade IV elementary students, who are in the concrete operational stage. At this stage, children learn most effectively when confronted with real objects and events that can be observed, manipulated, and explored directly. The activity of making pupur dingin, which involves observing the state change of rice, measuring the mass of ingredients using scales, and comparing temperatures before and after drying, provides concrete experiences highly relevant to students' learning needs. This aligns with the view of Hanifah et al. (2025), who asserted that literacy teaching materials based on local wisdom effectively improve student understanding because they present content close to their daily lives, such as local culture, traditions, and familiar local values.

The ease of use aspect refers to the level of convenience perceived by students and teachers in using the Si PURI worksheet, including clarity of instructions, readability of language, and ease of navigation in completing each activity. The results showed that the aspect of "ease of understanding instructions" obtained a score of 85.51% from students and 84.00% from teachers, while the aspect of "practicality in use" obtained a score of 83.33% from students and 85.00% from teachers. Although all aspects were in the very good category, the practicality aspect recorded the lowest score among the five aspects assessed by students. This indicates that although the Si PURI worksheet is generally easy to use, some students, especially those with literacy limitations or inclusive students, still require additional assistance in understanding instructions or completing certain activities.

This finding is relevant to the research results of Anggrayni et al. (2024), who developed local wisdom-based E-worksheets for grade IV elementary students, where the calculation results of the student response questionnaire obtained a score of 81.4% in the practical category. Kurino et al. (2025) also reported in the development of Problem-based Learning worksheets for mathematics in grade V elementary school that the level of practicality of use reached 89.83% based on positive responses from teachers and students. The slightly lower practicality figures for the Si PURI worksheet (83.33-85.00%) can be explained by the complexity of activities involving various STEAM elements simultaneously, as well as the diversity of literacy abilities of students at the research location, which included several inclusive students. Nevertheless, this achievement is still considered very good and indicates that the Si PURI worksheet can be used with assistance that is not excessive.

The main factor supporting the high ease of use aspect is the use of simple and communicative language, structured instructions, and the support of clear and contextual illustrations. Each activity in the Si PURI worksheet is equipped with step-by-step instructions arranged sequentially, so students can follow the learning flow without confusion. The presence of the characters Dayang and Emek as guides on every page of the Si PURI worksheet also plays an important role in guiding students, providing provocative questions, and directing discussions, thus effectively reducing the cognitive load students might experience when learning the integrated STEAM concepts.

The accuracy aspect in this study refers to the suitability of the Si PURI worksheet with the intended learning objectives, the Learning Outcomes of the Kurikulum Merdeka, and the characteristics and learning needs of grade IV elementary students. The teacher assessment results showed that the "depth of material" aspect obtained a score of 82.00%, which, although still in the very good category, was the lowest score among the four aspects assessed by teachers. This indicates that although the material in the Si PURI worksheet is generally accurate, there is still room for further deepening of some concepts, especially those related to explaining the changes in the state of matter in the rice fermentation process and the application of mathematics in calculating more complex ingredient ratios.

This finding aligns with the research results of Fikrina et al. (2023), who, in the development of MPPj etno-STEAM e-worksheets, stated that the product was declared feasible for use based on the feasibility test results by material experts and media experts, with the characteristics of the e-worksheet containing culture-based chemistry learning, integrated etno-STEAM, numeracy literacy indicators, and conservation character indicators. The accuracy of the Si PURI worksheet is also reflected in its success in integrating content from three subjects simultaneously, namely IPAS, Mathematics, and Fine Arts, in accordance with the demands of the Kurikulum Merdeka, which advocates for thematic-integrative learning at the elementary school level.

Furthermore, the research results conducted by Rofah & Ramadan (2025) on the development of a module based on Riau local wisdom for grade V elementary students showed that the developed module had

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met the feasibility criteria with a very high validity level after going through a revision process based on expert input. The final validation scores from material and language experts ranged from 92.5% to 95%, indicating that the module was "very feasible to use without revision." This finding strengthens the argument that teaching materials based on local wisdom, including the Si PURI worksheet, have a high level of accuracy because they are specifically designed to answer the contextual needs of students in a particular region.

The appropriateness aspect refers to the suitability of the Si PURI worksheet with the developmental level, emotional maturity, cultural background, and cognitive abilities of grade IV elementary students. The results showed that the aspect of "suitability with local culture" obtained a score of 86.23% from students and 88.75% from teachers, while the "interest" aspect reached 86.04% from students and the "attractiveness of visual design" aspect reached 88.41% from students and 88.00% from teachers. The highest achievement in the attractiveness of visual design aspect indicates that the Si PURI worksheet was successfully designed with an appearance suitable for the aesthetic preferences of elementary school-aged children, i.e., bright but not excessive colors, expressive and contextual illustrations, and a dynamic but orderly layout.

The appropriateness of the Si PURI worksheet is also reflected in the choice of the pupur dingin context, which is very close to the daily lives of students in East Kutai Regency. Most students already know and have even seen the use of pupur dingin by family members or people in their living environment. This closeness makes students feel that what they learn at school has direct relevance to their real world, thus their learning motivation increases significantly. This finding aligns with the research results of Hanifah et al. (2025), who developed literacy teaching materials based on local wisdom in Kuningan, where the teaching materials were considered effective because they presented content close to students' daily lives, such as local culture, traditions, and familiar values.

In addition, the research results conducted by Sari et al. (2026) also confirm that the digital worksheet developed for IPAS learning in grade IV elementary school shows high validity and practicality levels, with ease of use and good acceptance observed in the practicality test. This finding reinforces the conclusion that the Si PURI worksheet is not only feasible in content but also appropriate from the user's perspective because its design carefully considers the characteristics of the target audience.

Although overall the Si PURI worksheet is declared very accessible, there are several important notes to consider. First, the practicality in use aspect (83.33%) and depth of material aspect (82.00%) recorded the lowest scores among other aspects, indicating that some students, especially those with literacy limitations or special needs, still experience difficulties in working on the Si PURI worksheet independently. This finding aligns with the research results of Sari et al. (2026), who recommended the need for further testing on other subject matters and with larger samples to strengthen the findings, as actual classroom conditions have a higher level of ability diversity compared to controlled trial conditions.

Second, although the overall score is very good, there is quite significant variation in individual responses, with student scores ranging from 63 to 100. Students with the lowest scores were generally those with limitations in reading comprehension or who were inclusive students. This indicates that although the Si PURI worksheet is designed with simple language, additional assistance and differentiation strategies are still needed to accommodate the learning needs of all students equally.

Effectiveness of Si PURI Worksheet in Practicing Critical Thinking Skills of Fourth-Grade Elementary School Students

The results showed that the Si PURI worksheet is associated with an improvement in critical thinking skills of fourth-grade students at SD Negeri 017 North Sangatta, as evidenced by a significant increase in critical thinking skills scores from pretest to posttest. The class N-Gain value of 0.46 falls into the medium category, with 43.5% of students achieving the high improvement category. The Wilcoxon Signed Ranks Test results showed a significance value of 0.000 ($p < 0.05$), indicating a significant difference between students' critical thinking skills before and after learning using the Si PURI worksheet.

However, these findings should be interpreted with caution due to the research design employed, which is a single-group pretest-posttest design without a control group. This design, while appropriate for initial product effectiveness testing in development research (Nieveen & Folmer, 2013), does not allow for strong causal inference because several alternative explanations cannot be entirely ruled out, including: (a) history effects: external events occurring during the intervention period that may have influenced student outcomes; (b) maturation effects: natural cognitive development of students over time; (c) testing effects: familiarity

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with test instruments after the pretest that may improve posttest performance (Campbell & Stanley, 2015; Fraenkel & Wallen, 1990). Therefore, the improvement observed in this study can be interpreted as a promising indication of the Si PURI worksheet's potential effectiveness in fostering critical thinking skills, rather than as conclusive evidence of its causal impact. Subsequent research with a quasi-experimental or experimental design (e.g., pretest-posttest control group design) is recommended to establish stronger evidence of causality (Sugiyono, 2013). Nevertheless, within the context of product development research, these preliminary results provide valuable initial evidence that the Si PURI worksheet warrants further testing and wider implementation. The significant improvement found in this study is consistent with the findings of previous research on Ethno-STEAM-based learning, which suggested that integrating local cultural contexts with STEAM approaches can facilitate meaningful and contextual learning experiences that support the development of critical reasoning in elementary school students (Haryanto et al., 2024; Fikrina et al., 2023).

Achieving an N-Gain value of 0.46 in the medium category indicates that the Si PURI worksheet makes a positive contribution to improving students' critical thinking skills. Although the improvement is in the medium category, this achievement needs to be understood in the context of the diverse characteristics of the research subjects, including the presence of students with special needs (inclusive) and students who still have literacy limitations. This result is comparable to the findings of the development research of IPAS worksheets based on Experiential Learning conducted by Kusuma (2025), where the obtained N-Gain value reached 0.42 in the medium category for 23 grade V elementary students. Similarly, Bulan (2024), in the development of teaching modules and digital worksheets integrated with Etno-STEM, reported an N-Gain value of 0.45, which falls into the medium category for improving students' thinking abilities.

Comparison with these studies strengthens the argument that a medium category N-Gain value is a common and acceptable achievement in educational development research, especially when involving subjects with varying initial ability levels. More important than the magnitude of the N-Gain value is the fact that the improvement occurred consistently for the majority of students, with 43.5% of them even achieving the high improvement category. This achievement indicates that the Si PURI worksheet is not only effective on average but also capable of encouraging very significant leaps in ability for almost half of the students.

The effectiveness level of the Si PURI worksheet needs to be compared with various other similar worksheet development studies to obtain a more comprehensive picture. Research conducted by Anisa (2024) on the development of Discovery Learning E-worksheets integrated with Etno-STEM on the topic of the excretory system reported an N-Gain value of 0.70 in the high category, meaning that the developed media proved effective in practicing students' critical thinking skills. The higher N-Gain value in that study can be explained by several factors, including the educational level of the students (junior high school), who have more mature abstract thinking abilities compared to elementary students, and the topic (excretory system), which allows for more structured experiments and observations.

Meanwhile, research on the development of Problem-based Learning (PbL) worksheets on the topic of preserving natural and human resources conducted by Tari et al. (2025) proved its effectiveness with the results of the One Sample Test showing a t -count $>$ t -table and P -Value (1-tailed) $<$ 0.05, which means there was an increase in scores before and after using the worksheet. This finding aligns with the Wilcoxon test results in this study, which also showed statistical significance ($p = 0.000$). Damayanti & Raohman (2025) in their research on PbL-based worksheets for science learning in elementary schools also reported that the experimental class experienced a significant increase in all critical thinking indicators with statistical tests ($p < 0.001$) and a large effect size (Cohen's $d = 1.65$ - 2.45), thus concluding that PbL-based worksheets are effective in cultivating critical thinking skills in elementary school students.

The most relevant study for comparison is the development of Etno-STEM-based E-worksheets for processing sate bandeng conducted by Aulia (2026). That study obtained an average validity value of 91.5% in the very valid category and received a positive response from students of 86.8%. Although that study focused on the junior high school level, the similarity in the Etno-STEM approach provides a meaningful comparison framework. The Si PURI worksheet has a specific advantage because it was developed for the elementary level (grade IV) and uses the pupur dingin context, which is very specific to East Kalimantan, thus being more contextual for the research subjects.

The effectiveness of the Si PURI worksheet in practicing critical thinking skills is inseparable from a strong theoretical foundation, particularly constructivism theory and Ausubel's meaningful learning theory. The Etno-STEAM approach integrated into the Si PURI worksheet provides opportunities for students to build their own knowledge through direct experience (learning by doing) in the process of making pupur dingin. Activities such as observing the texture change of soaked rice, measuring the mass of ingredients

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using scales, comparing the effectiveness of traditional tools (ulin wooden mortar) with modern tools (blender), and designing packaging with Kutai batik motifs are all forms of contextual learning that require students to be actively involved in higher-order thinking processes.

The process of making pupur dingin, which involves rice fermentation, grinding, drying, and packaging, contains very rich STEAM content. From the science aspect, students learn about changes in the state of matter, fermentation, and the cooling sensation due to evaporation. The technology and engineering aspects are reflected in the use of traditional and modern tools, which opens up discussion spaces about efficiency and the working principles of each tool. The arts aspect is seen in the packaging design integrating the East Kutai batik motif, while the mathematics aspect is present in activities of measuring and calculating ingredient compositions. The integration of all five STEAM elements simultaneously in one authentic learning activity is a key factor distinguishing the Si PURI worksheet from conventional teaching materials.

This aligns with the findings of research conducted by Fendy (2025) at the State University of Surabaya, which developed an ethnomathematics worksheet based on the architecture of the Al Abror Mosque in Sidoarjo. The results of that study showed a very significant improvement in students' critical thinking skills, from an average pretest score of 34.20 to 87.87 on the posttest, with an N-Gain of 0.8199 (high category) and the results of the paired sample t-test showing a p-value < 0.001 . The higher N-Gain achievement in that ethnomathematics study can be explained by the narrower focus (only on one subject, mathematics) and the use of architectural objects that are permanent and can be observed repeatedly, unlike the pupur dingin manufacturing process, which is dynamic and requires a more complex sequence of steps.

One important finding in this study is the distribution of improvement in critical thinking skills, which shows variation among students. A total of 10 students (43.5%) achieved the high improvement category, 6 students (26.1%) the medium category, 4 students (17.4%) the low category, and 3 students (13.0%) showed no improvement. This variation reflects the field reality that each student has a different learning pace and style, as well as an unequal level of initial readiness. Students who achieved high improvement were generally those who actively participated in each stage of the activity, had high learning motivation, and were accustomed to exploration and discussion activities. In contrast, students who did not show improvement were mostly students with special needs (inclusive) or those with literacy limitations, thus requiring more intensive assistance and more time to understand instructions and complete the given activities.

This finding confirms what was identified in the research by Azizah (2024) on the development of reaction rate worksheets based on PbL integrated with TPS, that the effectiveness of worksheets in practicing critical thinking is influenced by various factors, including the implementation of the learning model used. In the context of the Si PURI worksheet, the success of implementation highly depends on the teacher's role in providing appropriate scaffolding, especially for students experiencing difficulties. This shows that even a good worksheet will not be effective without being balanced with a differentiated assistance strategy.

The results of the Wilcoxon Signed Ranks Test showing a significance value of 0.000 ($p < 0.05$) statistically prove that there is a significant difference between students' critical thinking skills before and after learning using the Si PURI worksheet. The selection of the Wilcoxon test was based on the normality test results showing that the pretest and posttest data were not normally distributed (Sig. < 0.05), so the parametric paired sample t-test could not be used. The negative Z value (-3.487) indicates that posttest scores are consistently higher than pretest scores.

This statistical significance aligns with the research findings of Tari et al. (2025), who also proved the effectiveness of PbL-based worksheets through the One Sample Test with a P-Value (1-tailed) < 0.05 . Similarly, research by Damayanti & Rohman (2025) reported that the improvement in critical thinking skills in the experimental class was statistically significant with $p < 0.001$ and a large effect size (Cohen's $d = 1.65-2.45$). Thus, the Wilcoxon test results in this study not only indicate a descriptive improvement but also confirm that this improvement is statistically meaningful and did not occur by chance.

Although generally the Si PURI worksheet proved effective, there are several limitations to note. First, the medium category N-Gain value (0.46) indicates that the improvement in critical thinking skills still needs to be further optimized. This can be done by enriching activities that specifically target high-level critical thinking indicators, such as evaluating arguments and synthesizing information, and increasing the frequency of practicing reasoning-based questions. Second, the presence of 3 students who did not show improvement indicates the need for developing more personalized assistance strategies, especially for inclusive students and those with literacy limitations.

These limitations do not mean that the Si PURI worksheet is ineffective; rather, effectiveness needs to be understood as a product of the interaction between the quality of teaching materials, the teacher's competence

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in facilitating, student readiness, and the support of the learning environment. As emphasized in the research by Azizah (2024), the effectiveness of worksheets in practicing critical thinking skills is not only determined by the validity of the product but also by the implementation of the learning model and the active involvement of students in each stage of the activity.

Conclusion

Based on the research results and discussion presented, three main conclusions can be drawn. First, this study successfully produced the Si PURI worksheet, an Ethno-STEAM-based student worksheet integrated with the local cultural context of pupur dingin, which was declared valid by expert validators and met the feasibility standards for content, didactic, construction, and technical presentation requirements. Second, the Si PURI worksheet demonstrated a high level of practicality based on assessments from teachers and students, indicating its usability, ease of use, clarity, and appropriateness for fourth-grade students. Third, the worksheet showed a significant association with improved critical thinking skills among the 23 participating students, as indicated by a moderate N-Gain score and a statistically significant difference between pretest and posttest scores. These findings suggest that the Si PURI worksheet has promising potential to foster critical thinking skills in elementary school students.

The main contributions of this research are threefold: (a) it provides a concrete example of how local wisdom (pupur dingin) can be systematically integrated into Ethno-STEAM-based teaching materials for elementary education; (b) it offers a validated and practical worksheet product that can be directly utilized by teachers in East Kalimantan or adapted by educators in other regions with their respective local cultural contexts; and (c) it contributes to the limited body of empirical research on the development of Ethno-STEAM-based LKPD specifically targeting critical thinking skills at the fourth-grade elementary level.

In terms of implications, this study offers practical guidance for elementary school teachers to design contextual and culturally responsive learning materials that bridge the gap between abstract scientific concepts and students' daily experiences. The Si PURI worksheet can serve as a model for integrating local cultural heritage into the Kurikulum Merdeka while simultaneously addressing the development of higher-order thinking skills. Additionally, this research provides a reference for future researchers to develop similar products in different cultural contexts or to strengthen the evidence base through more rigorous experimental designs.

It is important to note that these conclusions are based on a single-group pretest-posttest design involving 23 students from one elementary school in East Kutai Regency, East Kalimantan. Therefore, the findings should be interpreted as preliminary evidence within the specific context of this study, and generalization to broader populations should be made cautiously. Further research with larger sample sizes, control groups, and longer implementation periods is recommended to confirm the effectiveness of the Si PURI worksheet in diverse settings.

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