



Implementation of the STEAM-Ethnosains Carita-based science learning model to enhance the creativity and critical thinking of primary school students

Desyi Rosita^{1,2*} (✉), Sigit Prasetyo¹, Sintha Sih Dewanti¹, Sangkot Sirait¹.

¹Universitas Islam Negeri Sunan Kalijaga Yogyakarta, Indonesia

²Sekolah Tinggi Agama Islam Syekh Manshur Pandeglang, Indonesia

*Corresponding author's email: 24304081007@student.uin-suka.ac.id

Abstract

This research employed a descriptive qualitative approach to explore the implementation of the STEAM–Ethnoscience Carita-based science learning model in a primary school classroom to enhance students' creativity and critical thinking skills. Data were collected through participatory observation, semi-structured interviews, and documentation, involving teachers, students, school leaders, and local community members. Student creativity and critical thinking development were identified through classroom observations, learning artifacts, and thematic analysis of learning activities during the implementation of the model. The findings indicate that integrating STEAM principles with local ethnoscience knowledge, particularly traditional agricultural practices, water management, and environmental conservation in the Carita community, significantly improved the quality of science learning. Contextual learning activities encouraged active student engagement, strengthened conceptual understanding, and fostered environmental awareness. The results also show a substantial improvement in students' creativity and critical thinking abilities during the learning process, as reflected in their ability to generate ideas, analyze problems, and propose solutions during project-based activities. These findings demonstrate that the STEAM–Ethnoscience Carita model provides an effective pedagogical framework for developing 21st-century competencies in primary education and offers potential for adaptation in other educational contexts with similar cultural and ecological characteristics.

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1. Introduction

Advances in science and technology in the 21st century have brought about significant changes to educational practice, particularly at the primary school level (Blyznyuk et al., 2025). Science education is no longer solely focused on the mastery of theoretical concepts, but is also directed towards the development of higher-order thinking skills, such as creativity and critical thinking, which are essential competencies for addressing global challenges (Fatma et al., 2023). In this context, science education in primary schools plays a strategic role in shaping



a scientific mindset, fostering curiosity, and developing pupils' concern for the environment from an early age (Agustini et al., 2024). Therefore, science learning needs to be designed in an innovative and contextual manner so that it can encourage pupils' active engagement and optimally develop 21st-century skills (Fajrina et al., 2020).

One learning approach that has received widespread attention in the science education literature is the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach (Kang, 2019). This approach emphasizes cross-disciplinary integration through authentic, problem-solving-based learning experiences, enabling students to develop conceptual understanding alongside creative and critical thinking skills (Raihana et al., 2025). A number of studies indicate that STEAM-based learning can enhance student engagement, collaborative skills, and creativity in solving complex problems by linking scientific concepts to real-life contexts (Kurniawati & Daryusti, 2026). At the primary school level, the implementation of the STEAM approach has the potential to foster an interest in learning science whilst building an early foundation for the development of students' scientific reasoning and creativity (Najib et al., 2023).

Nevertheless, the implementation of the STEAM approach within the context of education in Indonesia still faces various challenges (Olaofe & Wibowo, 2025). Several studies indicate that classroom teaching practices remain dominated by conventional, teacher-centered approaches, meaning that pupils' opportunities for independent exploration, scientific investigation, and problem-solving remain relatively limited (Fufa et al., 2023). Furthermore, science teaching materials at the primary school level tend to be abstract and text-based, and do not yet fully link scientific concepts to social and cultural contexts relevant to pupils' lives (Park et al., 2020). This situation results in the science learning process being less meaningful and not yet optimal in developing higher-order thinking skills (Antonio & Prudente, 2024).

This issue is also reflected in the results of international assessments. Data from the Program for International Student Assessment (PISA) show that Indonesian students' creative thinking and scientific reasoning skills remain at a relatively low level compared to those of many other countries (Martens et al., 2016). These findings suggest that science education still requires pedagogical innovation capable of integrating conceptual mastery with the development of higher-order thinking skills (Baharin, 2018). Therefore, a learning approach is needed that is not only integrative but also contextual and relevant to students' life experiences, so that the learning process becomes more meaningful and effective in fostering creativity and critical thinking skills on an ongoing basis (Wang et al., 2019).

One approach that has the potential to address these challenges is the integration of science education with ethnoscience (Nasution & Nasution, 2026).

Ethnoscience refers to a system of knowledge that has evolved from cultural practices and the interactions of local communities with their natural environment (Okta & Saefullah, 2025). The integration of ethnoscience into science education enables students to understand scientific concepts through relevant cultural contexts, thereby fostering connections between modern science and local wisdom (Sudirman et al., 2025). Previous research indicates that ethnoscience-based learning can enhance students' understanding of scientific concepts, their engagement in the learning process, and their appreciation of local culture (Ardianti & Raida, 2022). Furthermore, this approach also contributes to fostering students' ecological awareness through an understanding of sustainable local practices.

However, most research on ethnoscience in science education still focuses on the integration of local cultural elements as a learning context, and has not yet systematically integrated the STEAM approach into a structured pedagogical framework (Lubis & Baiduri, 2025). On the other hand, research on STEAM learning generally places greater emphasis on the integration of academic disciplines and the development of 21st-century skills, but has not extensively examined the utilization of local wisdom as a contextual learning resource (Rafiquz-Zaman et al., 2025). Consequently, there remains a research gap regarding the development of a learning model that systematically integrates the STEAM approach with ethnoscience within the context of primary education to enhance pupils' creativity and critical thinking skills (Najib & Suprihatiningrum, 2025).

The local context of Carita holds significant potential as a source of ethnoscience-based learning (Suciyati et al., 2021). This region possesses traditional agricultural systems and environmental conservation practices that reflect scientific and ecological principles, such as water management, crop rotation, and the sustainable use of natural resources (Kremsa, 2021). These local practices can serve as an authentic context for science learning in primary schools. For pupils, learning that draws on local phenomena and practices will make abstract scientific concepts more concrete, contextual, and easier to understand.

Against this backdrop, this study aims to design, implement, and evaluate a STEAM-based science learning model known as *Ethnosains Carita*, which integrates STEAM principles with local knowledge on agricultural practices and environmental conservation in the Carita region (Kartamiharja, 2025). The main objective of this research is to improve pupils' conceptual understanding, critical thinking skills, and creativity through contextual, project-based learning that is closely related to their socio-cultural environment. Through project-based learning activities, exploration of local phenomena, and scientific experiments, pupils are encouraged to actively construct knowledge while engaging in meaningful learning processes (Williamson, 2023).

In addition, this study seeks to examine the effectiveness of the *Ethnosains Carita* model in fostering active learning, enhancing student engagement, and developing higher-order thinking skills compared to conventional science instruction. The contribution of this research lies in offering an innovative and culturally responsive learning model that bridges modern STEAM education with local wisdom. Furthermore, this study provides empirical evidence and practical guidance for educators in integrating ethnoscience into science learning, thereby supporting sustainable education practices and strengthening the relevance of science education to real-life contexts.

Creativity and critical thinking are two key competencies in 21st-century education that need to be developed from an early age (Ellerton & Kelly, 2022). Creativity encompasses the ability to generate original ideas, interpret information, and apply scientific concepts in new situations. Meanwhile, critical thinking relates to the ability to evaluate evidence, identify cause-and-effect relationships, and make rational decisions (Місечко & Литньова, 2022). STEAM–ethnoscience-based learning provides an effective pedagogical framework for developing both of these competencies through inquiry, discussion, and problem-solving activities rooted in authentic local contexts (Azizah et al., 2025).

The implementation of the Carita STEAM–Ethnoscience learning model is grounded in constructivist and sociocultural learning theories, as proposed by Jean Piaget and Lev Vygotsky. These theories emphasize that knowledge is actively constructed through interaction with the environment and shaped by social and cultural contexts. In this study, pupils learn through direct engagement with local agricultural and environmental phenomena, allowing them to build conceptual understanding in a meaningful and contextual way. The integration of ethnoscience further reinforces culturally responsive learning by positioning local knowledge as a valid and relevant source of scientific understanding.

In addition, this research is supported by the STEAM education framework and project-based learning (PBL) approach, which are aligned with the Merdeka Belajar policy. These frameworks promote interdisciplinary, student-centered, and exploratory learning that fosters critical thinking, creativity, collaboration, and problem-solving skills. Within this study, these theories serve as a conceptual foundation and analytical lens to evaluate how the *Ethnosains Carita* model enhances pupils' engagement, higher-order thinking skills, and overall learning outcomes.

This study is urgent because science learning in primary schools often remains abstract and disconnected from pupils' real-life contexts, resulting in low levels of creativity and critical thinking. At the same time, the growing demands of 21st-century competencies require learning models that are not only innovative but also relevant to students' socio-cultural environments. By integrating STEAM

with ethnoscience based on local agricultural and environmental practices in Carita, this research addresses the gap between global educational demands and local contextual needs. Therefore, the study becomes important as it offers a concrete solution to make science learning more meaningful, contextual, and capable of developing higher-order thinking skills from an early age.

The benefits of this research are both theoretical and practical. Theoretically, it contributes to the development of science education by providing an empirical model that integrates STEAM and ethnoscience in a systematic and measurable way. Practically, the findings can be used by teachers as a reference for designing contextual and culturally responsive learning, by schools as a basis for curriculum development, and by communities as a means of preserving and utilizing local knowledge related to agriculture and environmental conservation. In this way, the study not only advances educational innovation but also supports the strengthening of cultural identity and ecological awareness in society.

2. Methods

This study utilized a descriptive qualitative approach aimed at obtaining an in-depth understanding of the implementation of the STEAM–Ethnosains Carita-based science learning model, which encompassed the stages of planning, implementation, and evaluation, as well as examining its contribution to the development of creativity and critical thinking skills among primary school students (Bradshaw et al., 2017). This approach was chosen because it enables researchers to examine the learning process contextually and naturally in accordance with actual classroom conditions.

The research was conducted at Public Elementary School of Pandeglang, Banten Province, during the even semester of the 2025/2026 academic year. The research site was selected purposively because the surrounding community possesses strong ethnoscience potential relevant to the Carita context, particularly traditional agricultural practices and local environmental conservation activities that can be integrated into science learning.

Research participants were selected using a purposive sampling technique. The participants of this study consisted of four key groups: a Grade 5 science teacher served as the primary implementer of the classroom learning model, 30 Grade 5 students who experienced the learning process and whose creativity and critical thinking skills were assessed, principal who provided insights into school policies and support for implementing learning models, and a local farmers was involved as a community informant to contribute contextual knowledge related to agricultural practices and environmental conservation in the Carita region.

In qualitative research, the researcher served as the primary instrument, supported by auxiliary instruments including observation guidelines, semi-

structured interview guidelines, and documentation sheets. Data validity was ensured through source triangulation and technique triangulation, as well as member checking and referential adequacy. Instrument validity was established through expert judgment, while reliability was maintained through consistent observation and systematic data recording.

Data were collected through participatory observation, semi-structured interviews, and documentation. Observations focused on student engagement during learning activities, the integration of STEAM elements, the application of Carita ethnoscience, and students' creative and critical thinking behaviors. Semi-structured interviews were conducted to explore teachers' perspectives, students' learning experiences, and the relevance of local cultural knowledge in science learning. Documentation, including lesson plans, student worksheets, photographs, and learning artifacts, was used as supporting evidence to strengthen the findings.

To analyze the development of students' creativity and critical thinking skills during the implementation of the learning model, the study employed several indicators adapted from previous research on 21st-century skills and science education.

Table 1.

Indicators of students' creativity

No	Indicator	Description
1	Fluency	Ability to generate multiple ideas or solutions when facing scientific problems
2	Flexibility	Ability to view problems from different perspectives and apply various approaches
3	Originality	Ability to produce unique or novel ideas related to scientific concepts
4	Elaboration	Ability to develop and refine ideas into more detailed and systematic explanations

Table 2.

Indicators of students' critical thinking

No	Indicator	Description
1	Problem Identification	Ability to recognize and formulate scientific problems clearly
2	Evidence Evaluation	Ability to analyze and evaluate information or experimental results
3	Reasoning and Interpretation	Ability to explain relationships between concepts and interpret scientific data
4	Decision Making	Ability to draw logical conclusions and propose solutions based on evidence

Data analysis was conducted using the interactive model of Miles and Huberman, which consists of three stages: data reduction, data display, and conclusion drawing/verification (Qomaruddin & Sa'diyah, 2024). Data reduction involved coding and categorizing data based on the research focus. Data were presented as thematic narratives, tables, and interview excerpts to facilitate

interpretation. Finally, conclusions were drawn through continuous verification and triangulation to ensure the credibility and validity of the findings.

3. Results

3.1 Implementation of the STEAM-Ethnosains Carita-based science learning model in the Public Primary School of Pandeglang

The implementation of the STEAM-based ethnoscience Carita science learning model at the Public Primary School (MIN) of Pandeglang demonstrates a strong integration of modern scientific concepts with local cultural practices that are alive in Carita society. This model integrates STEAM (Science, Technology, Engineering, Arts, and Mathematics) interdisciplinary principles with ethnoscience knowledge sourced from traditional agricultural practices, water conservation, and environmental management. This integration supports contextual, meaningful, and relevant learning for students, as it is emphasized that culture-based interdisciplinary learning can improve conceptual understanding and knowledge retention among primary school students.

In practice, science teachers act as facilitators who design exploratory, project-based, and experiential learning activities. Learning activities are carried out in an integrated manner between classroom learning and outdoor learning, particularly in the rice fields and gardens around the school. In the photosynthesis material, for example, students make direct observations of rice plants, measure light intensity, monitor soil conditions, and analyze plant water requirements. These activities enable students to relate abstract science concepts to agricultural practices that are familiar in the daily life of the Carita community.

The results of the interview analysis with the teacher (R1) indicate that the STEAM–Ethnoscience learning model was implemented adaptively despite limitations in time and learning facilities. The coding process identified several key keywords, namely "limited resources", "use of the environment", "simple materials", "adaptive strategies", and "teacher creativity". These findings show that teachers consistently utilize locally available resources as alternative learning media to support the sustainability of the learning process.

This is evidenced by several authentic interview excerpts. The teacher stated, "The facilities at the school are limited, but we used the surrounding environment as a learning resource." In addition, the teacher explained, "We used bottles, soil samples, and rice plants as a medium to explain the concept directly." The teacher also emphasized, "A simple measuring tool is enough to help students understand the material, which is important that they are actively involved." These statements confirm that the teacher applied adaptive strategies by integrating simple materials and environmental resources, which in turn

supported the effective and sustainable implementation of the STEAM–Ethnoscience model while fostering students’ active participation in learning.

Systematic observations were conducted during classroom and field learning activities using observation sheets that covered student engagement, application of scientific concepts, inquiry behavior, collaboration, and environmental awareness. The results of the observations showed a high level of student engagement and meaningful learning interactions.

Table 3.

Summary of observation results of STEAM-Ethnoscience-based science learning

Observed Aspect	Indicator Description	Percentage (%)
Student Engagement	Active participation in classroom and field activities	90
Application of Science Concepts	Ability to relate science concepts to agricultural practices	85
Inquiry Behavior	Ability to pose analytical and causal questions	80
Collaboration	Group cooperation and problem-solving discussions	88
Environmental Awareness	Reflection on environmental conservation and sustainability	82

Table 3 indicates that the STEAM–Ethnosains Carita model is effective in facilitating inquiry-based learning and direct experience. The learning environment functions as a living laboratory that enables students to actively construct knowledge through direct interaction with the natural and social phenomena around them. In addition, the results of interviews with students (R2) showed very positive responses to the implementation of this learning model. Students stated that learning activities outside the classroom, particularly direct observation in the fields, increased their interest in learning, enjoyment, and ease in understanding science material. Authentic learning experiences helped students understand the concepts of light, water, and plant growth more concretely than learning based solely on textbooks.

Institutional support and community involvement are important factors in the successful implementation of this model. Interviews with school stakeholders (R3) and the local community (R4) revealed close collaboration between the school and the Carita community. The community provides access to agricultural land, gardens, and conservation areas as contextual learning resources for students.

Furthermore, documentation data in the form of photographs and field notes support the findings from observations and interviews. The documentation shows students actively involved in observing plant growth, mapping irrigation flows, and collaborating in discussions in an agricultural environment. This visual evidence reinforces the validity of the data and demonstrates the authenticity of the STEAM–Ethnoscience-based learning.



Fig. 1. Students' contextual learning activities in the Carita rice fields



Fig. 2. Students conducting environment-based science learning in a rice field area

The results of teacher observations and assessments showed a significant increase in students' creativity and critical-thinking skills following the implementation of the learning model (see Table 4). This improvement is reflected in the students' ability to generate original ideas, interpret observational data, and provide logical explanations for the scientific phenomena observed.

Table 4.

Changes in students' creativity and critical thinking skills

Aspect	Pre-Implementation (%)	Post-Implementation (%)
Creativity	45	80
Critical Thinking Ability	50	85

In addition to improving higher-order thinking skills, students' science literacy also improved significantly. Pre- and post-learning assessments showed an increase in students' understanding of scientific concepts, processes, and applications in real-life contexts (see Table 5).

Table 5.

Improvement in Student Science Literacy

Assessment Stage	Science Literacy (%)
Before learning	60
After learning	90

These results indicate that integrating STEAM and ethnoscience effectively strengthens students' ability to understand and apply scientific knowledge in meaningful ways. Overall, the results of the study show that the STEAM-Ethnoscience Carita-based science learning model is able to increase learning engagement, creativity, critical thinking skills, and science literacy among primary school students. The integration of STEAM principles with the local cultural and environmental context, supported by collaboration between schools and communities, produces authentic and meaningful learning experiences. This

model has strong potential to be replicated in other primary school contexts with similar cultural and environmental characteristics.

3.2 Enhancing creativity through the integration of STEAM and local ethnoscience, Carita

The integration of the STEAM approach with local ethnoscience in Carita has significantly enhanced the creativity of primary school students. Project-based learning and environmental exploration enable students to build conceptual understanding through real-world experiences contextualized to the lives of the Carita community. Students' creativity develops through observation, analysis of environmental problems, and the design of simple solutions based on local knowledge, in line with the findings. In addition, observations during the learning process showed an increase in students' creative behavior, particularly in terms of fluidity of ideas, flexibility of thinking, and courage to express ideas. A summary of the observation findings is presented in Table 6.

Table 6.

Results of observation of students' creative behavior in STEAM–Ethnoscience Learning

Creativity Aspect	Observation Indicator	Percentage (%)
Fluency of ideas	Presenting many ideas during discussions	85
Flexibility of thinking	Offering alternative solutions to environmental issues	80
Originality	Unique ideas based on local practices	78
Elaboration	Developing ideas in detail	82
Courage of expression	Actively asking questions and expressing opinions	88

Table 6 indicates that the majority of students displayed creative behavior at a high level. This means that a contextual learning environment based on local culture encouraged students to express themselves more freely and develop ideas independently. This finding aligns with results of interviews with teachers (R1) and students (R2) indicated that STEAM–Ethnoscience learning helped students connect science concepts with agricultural practices and environmental conservation in Carita. To reinforce these qualitative findings, respondents' perceptions are summarised in Table 7.

Table 7.

Teachers' and Students' Perceptions of the Impact of STEAM–Ethnoscience Learning

Respondent	Assessed Aspect	Key Findings
R1	Understanding of science concepts	Easier to understand and more contextual
R1	Critical and creative thinking activities	Students are more active in asking questions and arguing
R2	Interest in learning science	Increased due to hands-on field learning
R2	Ability to connect theory with practice	Faster and more concrete

The findings in Table 7 confirm that integrating STEAM with local ethnoscience not only improves conceptual understanding but also strengthens students' affective and creative dimensions in science learning. Based on teacher assessments and creativity rubrics, there was a significant increase in student creativity levels after the implementation of STEAM–Ethnosains Carita learning. A comparison of creativity achievements is presented in Table 8.

Table 8.

Comparison of student creativity levels before and after learning

Creativity Indicator	Before Implementation (%)	After Implementation (%)
Fluency of ideas	50	85
Flexibility	48	80
Originality	45	78
Elaboration	52	82
Average	49	81

Improvements in all indicators show that STEAM–Ethnosains Carita learning is effective in stimulating student creativity. Field observation activities, contextual discussions, and environment-based problem solving play an important role in encouraging divergent and innovative thinking skills.

The learning documentation (Figures 3 and 4) shows students' active involvement in plant observation, agricultural processing, and group discussions in the rice field environment. Interviews with the community (R4) reinforce that students show an increased interest in scientific activities and environmental awareness, as reflected in their habit of asking questions and their involvement in local agricultural and conservation practices. Overall, the observation data.



Fig. 3. Students conducting field observations on plants



Fig. 4. Student activities in STEAM-ethnoscience learning in rice field areas

Vases, interviews, and documentation, reinforced by quantitative-descriptive tables, show that integrating STEAM with local Carita ethnoscience significantly increases the creativity of primary school students. This authentic and contextual learning not only enriches the understanding of science concepts

but also shapes creativity, critical thinking, and ecological awareness as part of 21st-century skills.

Furthermore, a summary of the observation results about critical thinking indicators during learning activities in the classroom and in the field, including the ability to observe, analyze cause and effect, evaluate information, and draw conclusions is presented in Table 9.

Table 9.

Students' critical thinking skills in STEAM–ethnoscience learning

Indicators of critical thinking	Description of observed behavior	Percentage (%)
Analytical observation	Observing phenomena systematically and purposefully	88
Cause–and–effect analysis	Explaining relationships among environmental variables	85
Solution evaluation	Assessing the effectiveness of proposed solutions	80
Drawing conclusions	Concluding observations based on evidence	83
Scientific argumentation	Presenting opinions supported by logical reasons	86

The findings in Table 9 show that most students have achieved a high category on the critical thinking indicators. Real-world problem-based learning activities, such as water pollution and agricultural soil conditions, encourage students to engage in scientific inquiry and reflection actively. These findings align with the results of interviews with teachers (R1), students (R2), school officials (R3), and the community (R4), which showed consistent perceptions regarding the improvement of students' critical thinking skills. A summary of the interview findings is presented in Table 10.

Table 10.

Summary of respondents' perceptions of students' critical thinking skills

Respondent	Observed Aspect	Key Findings
R1	Analysis and problem solving	Students are able to analyze problems and design solutions
R2	Logical reasoning	Students regularly seek reasons based on observations
R3	Argumentation and reflection	Students are more critical in asking questions and expressing opinions
R4	Scientific curiosity	Students do not easily accept information without justification

The findings in Table 10 show that STEAM–Ethnosains Carita-based learning encourages students to think more deeply, reflectively, and rationally about natural phenomena and environmental practices around them. In addition, the comparison of critical thinking skills before and after the implementation of

STEAM–Ethnoscience learning, using an assessment rubric based on higher-order thinking indicators, is presented in Table 11.

Table 11.

Comparison of Students' Critical Thinking Skills Before and After Implementation

Indicator	Pre-Implementation (%)	Post-Implementation (%)
Observation and identification	52	88
Cause–and–effect analysis	50	85
Evaluation and reflection	48	80
Drawing conclusions	55	83
Average	51	84

Significant improvements across all indicators show that STEAM-based science learning – Ethnosains Carita is effective in developing students' critical thinking skills. Activities such as designing and testing simple water filtration devices (Figure 7) provide students with hands-on experience in applying scientific reasoning in real life.



Fig. 5. Students design and test a simple water filter.



Fig. 6. Student Activities When Learning Science Concepts in an Agricultural Environment

Based on the results of observations, interviews, and quantitative descriptive data, it can be concluded that integrating STEAM with local ethnoscience in Carita contributes significantly to the development of critical thinking skills among primary school students. Context-based learning enables students to analyze natural phenomena, evaluate information, and draw conclusions based on empirical evidence. Thus, the STEAM–Ethnoscience Carita model not only strengthens conceptual understanding of science, but also shapes critical thinking skills that are essential for 21st-century learning.

4. Discussion

4.1. Implementation of the STEAM–ethnoscience Carita model in science education

This study found that implementing the STEAM–Ethnoscience Carita learning model at the Public Primary School of Pandeglang creates a more contextual and meaningful science learning environment. Through field observations in rice fields, discussions about traditional agricultural systems, and simple experiments using local materials, students were able to relate abstract scientific concepts to real-life experiences. From a theoretical perspective, this learning process reflects the principles of contextual learning, which emphasize the importance of connecting academic content with real-world situations in order to enhance conceptual understanding and knowledge retention.

From the perspective of the STEAM framework, the learning activities implemented in this study demonstrate the integration of interdisciplinary components. Science concepts such as photosynthesis, ecosystem balance, and adaptation were explored through observation and experimentation; engineering principles were introduced through the design of simple irrigation and filtration systems, while artistic and creative expression emerged through the presentation and visualization of students' project findings. Thematic coding conducted during the data reduction stage of the Miles and Huberman analysis revealed that students' engagement increased significantly when learning activities involved direct interaction with environmental phenomena. These findings support the argument of Habsari et al. (2026) that experiential outdoor learning enhances students' motivation, curiosity, and engagement in science education.

The role of teachers also emerged as a critical factor in the successful implementation of the model. Data obtained from interviews with R1 (science teacher), analyzed through thematic categorization during the data display stage, indicated that teachers intentionally designed interdisciplinary activities that integrated scientific concepts with local environmental practices. This strategy aligns with the theoretical premise of ethnoscience-based learning, which emphasizes the incorporation of indigenous knowledge systems into formal education in order to make learning more culturally relevant. Similar findings were reported by (Lakapu et al., 2025), who argue that cross-disciplinary learning grounded in local wisdom enhances both the relevance and sustainability of scientific knowledge among students.

Furthermore, the involvement of local community members, such as farmers (R4), significantly enriched the learning process. During the verification stage of the data analysis, the integration of community knowledge enabled students to access practical insights into irrigation management, crop cultivation, and environmental conservation. This collaboration between schools and local communities supports the theoretical concept of situated learning, which posits

that knowledge acquisition occurs more effectively when learners participate in authentic social practices. Consistent with the findings of Wijayanto et al. (2025), the collaboration between schools and communities contributes to improved conceptual understanding and fosters positive attitudes toward environmental sustainability. This finding indicates that the implementation of the STEAM–Ethnoscience Carita model demonstrates that integrating scientific learning with local environmental practices can produce authentic learning experiences that are both meaningful and relevant for primary school students.

4.2. Enhancing Student Creativity through the Integration of STEAM and Carita Ethnoscience

Another significant finding of this study concerns the enhancement of students' creativity through the integration of STEAM principles with local ethnoscience knowledge. Creativity development was observed through students' ability to generate ideas, propose alternative solutions, and apply scientific concepts when engaging in project-based activities related to farming systems, water management, and environmental conservation. During the data reduction process, observation notes and student artifacts were coded into categories such as idea generation, problem exploration, and creative experimentation.

From a theoretical perspective, this finding supports the argument that creative thinking develops optimally when learning activities provide authentic problem contexts and opportunities for interdisciplinary exploration. The STEAM framework encourages such exploration by combining analytical thinking with design-based problem solving. These results are consistent with the work of Windyariani (2019), who emphasizes that creativity in science learning emerges when scientific concepts are connected to students' socio-cultural environments.

The interpretation of interview data also reinforces this conclusion. Statements from R1 (teacher) and R2 (students), analyzed through thematic interpretation during the data display stage, indicate that linking science content with local agricultural practices helped students better understand ecosystem relationships and environmental processes. Students reported that observing irrigation systems, plant growth patterns, and soil conditions enabled them to generate ideas about how environmental factors influence agricultural productivity. This suggests that contextual learning environments stimulate creative thinking by allowing students to actively interpret and reconstruct knowledge.

Beyond creativity, the integration of ethnoscience also strengthened students' scientific literacy and environmental awareness. According to interview data from R3 (head of the madrasah), students were able not only to understand theoretical explanations but also to explain practical agricultural processes using simple scientific reasoning. These findings align with the results of (Kariani et al.,

2025), who found that integrating local wisdom into science education enhances both conceptual understanding and critical engagement with environmental issues.

In addition, the involvement of local farmers (R4) provided authentic learning experiences that encouraged students to ask questions about soil fertility, composting processes, and plant water requirements. This observation suggests that the ethnoscience-based learning environment functions as a cultural bridge, connecting modern scientific knowledge with traditional ecological knowledge. Such integration supports the theoretical perspective that culturally responsive pedagogy can significantly enrich students' learning experiences and strengthen their environmental awareness (Guberina, 2023). These findings indicate that the integration of STEAM and ethnoscience not only enhances creativity but also fosters ecological awareness and scientific literacy, which are essential competencies for primary school students in the context of sustainable education.

4.3. Developing Critical Thinking Skills through STEAM–Ethnoscience Carita-Based Science Education

The study also demonstrates that STEAM–Ethnoscience Carita-based learning significantly contributes to students' critical thinking skills. The contextual and problem-based nature of the learning activities provided opportunities for students to analyze real-world problems, evaluate evidence, and formulate logical conclusions. During the data reduction phase, classroom observation notes were coded into several categories of critical thinking behavior, including problem identification, evidence evaluation, reasoning, and solution formulation.

Interview data from R1 (teacher) revealed that activities such as analyzing the causes of water pollution, designing simple water filtration systems, and testing the effectiveness of these designs enabled students to engage in systematic inquiry processes. Through these activities, students learned to observe patterns, compare alternative solutions, and evaluate the outcomes of their experiments. These findings support the theoretical argument presented by (Limori et al., 2025), which emphasizes that STEAM-based learning environments facilitate higher-order thinking by integrating inquiry, experimentation, and collaborative problem solving.

Furthermore, contextual learning in the Carita agricultural and coastal environment enabled students to reason about cause-and-effect relationships between environmental variables and agricultural outcomes. According to interview data from R2 (students), learners were able to relate agricultural phenomena to scientific concepts, such as understanding how soil salinity affects plant growth and water absorption. This indicates that students moved beyond memorization toward analytical reasoning based on empirical observation. Similar conclusions were reported by (Amirudin et al., 2025), who found that

inquiry-based learning grounded in local environmental contexts strengthens students' analytical reasoning abilities.

Additional evidence of the development of critical thinking emerged from interview statements by R3 (head of the madrasah) and R4 (farmer), which indicated that students increasingly asked analytical questions, compared different sources of information, and attempted to explain variations in plant growth using scientific reasoning. During the verification stage of the data analysis, these behavioral changes were interpreted as indicators of students' growing ability to engage in evidence-based reasoning rather than passively receiving information.

These findings also align with the results reported by Fatmi et al. (2026), which suggest that ethnoscience-based learning activities encourage students to develop hypotheses, test explanations, and engage in reflective thinking processes. From a broader perspective, the STEAM–Ethnoscience Carita model contributes to the development of scientific habits of mind, which are essential components of critical thinking in science education.

The findings of this study have several important practical implications and contributions for both the development of learning sciences and society. In practice, integrating STEAM pedagogy with ethnoscience provides teachers with a concrete, applicable model for designing contextual, meaningful, and student-centered science learning. Teachers can utilize local environmental resources and community knowledge as learning media, even in schools with limited facilities, thereby making learning more relevant and engaging. For schools and curriculum developers, this model can serve as a reference in developing adaptive curricula that align with 21st-century competencies while remaining rooted in local culture. From a societal perspective, this approach helps strengthen ecological awareness and preserve local wisdom, particularly in agricultural and environmental conservation practices, by involving the community as a learning resource.

In terms of scientific contribution, this study enriches the field of science education by offering an empirical model that systematically integrates STEAM and ethnoscience within a primary education context. It provides evidence that contextual and culturally responsive learning can effectively enhance students' critical thinking and creativity, thus supporting the development of innovative learning theories and practices. However, this study also has several limitations. First, the research was conducted in a single educational setting with a relatively small number of participants, which may limit the generalisability of the findings. Second, the implementation period was relatively short, so it may not fully capture the learning model's long-term impact. Third, the study focused primarily on creativity and critical thinking skills, without extensively examining other aspects such as collaboration or digital literacy. Therefore, future research is

recommended to involve broader contexts, longer implementation periods, and more diverse variables to strengthen the validity and applicability of the findings.

5. Conclusion

This study demonstrates that integrating a STEAM-based science learning model with Carita local ethnoscience significantly improves the quality of primary school science learning by creating contextual and authentic experiences rooted in traditional farming systems, water management, and environmental conservation; quantitatively, student engagement reached 90%, science concept application 85%, and environmental awareness 82%, showing the effectiveness of local culture in linking scientific concepts to real-life experiences, while students' creativity increased from 49% to 81% and critical thinking from 51% to 84%, reflected in their ability to generate original ideas, analyze cause–effect relationships, evaluate evidence-based solutions, and present logical scientific arguments through project-based learning, environmental exploration, and contextual problem solving, supported by strong collaboration between schools and the Carita community, which enhanced science literacy from 60% to 90% and fostered cultural and ecological awareness, positioning the Carita STEAM–Ethnosains model as an effective, sustainable, and replicable approach for developing 21st-century skills and informing local wisdom–based science education policies at national and international levels.

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