



ETHNOSCIENCE IN VERNACULAR ARCHITECTURE OF DAYAK TRADITIONAL HOUSES: A STUDY OF LOCAL KNOWLEDGE AS CONTEXTUAL SCIENCE LEARNING RESOURCES

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Abstract

Science learning in Indonesia is frequently delivered in an abstract manner that is detached from the cultural environment of learners, a condition that contributes to weak scientific literacy and limited appreciation of local wisdom. This study aims to identify the indigenous science embedded in the vernacular architecture of Dayak traditional houses and to reconstruct it into scientific concepts that can serve as contextual science learning resources. The study applied a qualitative descriptive design using an ethnoscience reconstruction approach. Data were gathered through literature study and documentation analysis of architectural features of the Dayak longhouse, namely the rumah betang and rumah radakng of Kalimantan, and were analysed through the stages of identifying indigenous knowledge, reconstructing it into scientific knowledge, and mapping it to the science curriculum. The findings reveal that core architectural elements carry rich scientific content. The elevated stilt structure encodes concepts of pressure, fluid statics, flood hydrology, and structural equilibrium. The use of ironwood relates to material density, mechanical strength, and biological decay resistance. The steep gable roof, the wooden peg joinery, the cross-ventilated and slatted floor, and the natural pigments respectively embody concepts of inclined-plane forces, elasticity and energy dissipation, convective heat transfer and the stack effect, and the chemistry of pigments. These reconstructed concepts align with topics in physics, chemistry, biology, and earth science across the secondary curriculum, and they fit project-based and inquiry learning that strengthens scientific literacy, cultural literacy, and the values of the Pancasila Student Profile. The study concludes that Dayak vernacular architecture is a strong and underused contextual learning resource that connects scientific reasoning with cultural identity and conservation values.

Keywords: ethnoscience vernacular architecture, Dayak longhouse, contextual science learning, local wisdom

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PENDAHULUAN

Science education in Indonesia continues to struggle with a persistent gap between the way concepts are taught and the lived experience of learners. Lessons are often delivered through formulas, definitions, and examples that originate from contexts far removed from the daily lives of students, so that science feels foreign rather than familiar. International assessments reinforce this concern, since the performance of Indonesian students in scientific literacy on the Programme for



International Student Assessment has remained below the average of participating countries for successive cycles. A central cause is the limited use of the cultural and natural surroundings of learners as a starting point for understanding scientific phenomena.

Ethnoscience offers a productive response to this problem. As a field of study, ethnoscience examines the systems of knowledge that a community holds about the natural world, including the ways a society classifies, explains, and acts upon its environment (Sturtevant, 1964). Scholars describe ethnoscience as a bridge that connects indigenous forms of knowledge with the conceptual structures of modern science, allowing each to inform the other rather than displacing one with the other (Rist & Dahdouh-Guebas, 2006). In the science classroom, this perspective treats the local culture not as decoration but as a genuine source of scientific reasoning that students can investigate, test, and relate to formal concepts.

A growing body of research in Indonesia has shown that reconstructing local knowledge into scientific knowledge improves the contextuality and meaning of learning. The reconstruction approach, refined through the work of Sudarmin and colleagues, moves systematically from the original knowledge held by a community toward its explanation in scientific terms, and then toward its organisation as a learning program (Khusniati, Parmin, & Sudarmin, 2017; Sudarmin et al., 2018). Studies have applied this approach to batik dyes, traditional medicine, local food, and farming practices, and have reported gains in conceptual understanding, scientific literacy, and conservation values (Dewi, Khery, & Erna, 2019; Widiyatmoko, Sudarmin, & Khusniati, 2015). Contextual learning grounded in ethnoscience has also been linked to higher learning activity among students (Rahmawati, Subali, & Sarwi, 2019) and to more positive attitudes toward science (Fasasi, 2017).

This direction sits comfortably within current national policy. The Merdeka Curriculum and the Pancasila Student Profile both call for learning that is contextual, that nurtures critical and creative thinking, and that strengthens cultural identity alongside scientific competence. Local wisdom therefore becomes more than a cultural ornament. It becomes a pedagogical resource that helps students see science as something rooted in their own communities.

West Kalimantan offers an especially rich, yet underused, reservoir of such knowledge in the vernacular architecture of the Dayak people. The Dayak longhouse, known as the rumah betang in Central and West Kalimantan and as the rumah radakng among Dayak communities of West Kalimantan, is a communal dwelling that can stretch for tens or even hundreds of metres and that shelters many related families under one roof. Beyond its social and spiritual meaning, the building embodies a refined response to a hot, humid, and flood-prone tropical environment. The structure stands on tall wooden stilts, uses dense and durable ironwood, carries a steep gabled roof, relies on flexible wooden joinery, and is sited along rivers to capture breeze, light, and access to water. Each of these choices reflects accumulated practical knowledge that can be read through the lens of physics, chemistry, biology, and earth science.

Despite this potential, most ethnoscience research in science education has concentrated on ethnobotany, ethnomedicine, and food traditions, while vernacular architecture has received comparatively little attention. The architectural heritage of the Dayak in particular remains rarely examined as a source of contextual science content, even though it is visible, durable, and deeply meaningful to local learners. This study addresses that gap. It pursues two objectives. The first is to identify the indigenous science embedded in the vernacular architecture of Dayak traditional houses. The second is to reconstruct this knowledge into scientific concepts and to map it as a contextual resource for science learning in line with the secondary school curriculum.

METHOD

Research Design

This study used a qualitative descriptive design with an ethnoscience reconstruction approach. The design is appropriate because the study seeks to describe and interpret a cultural artefact and to transform the knowledge it carries into scientific explanation rather than to test a hypothesis. The

reconstruction approach follows the logic developed in earlier ethnoscience studies, which move from the original knowledge of a community toward its restatement in scientific terms and then toward its arrangement as a learning resource (Khusniati et al., 2017; Sudarmin et al., 2018). The analytical framing also draws on the Model of Educational Reconstruction, which links the clarification of subject matter with the design of learning environments (Duit, Gropengiesser, & Kattmann, 2005).

Data Sources

The objects of study were the architectural features of the Dayak longhouse, including the stilt structure, the choice of building material, the roof form, the joinery system, the ventilation arrangement, the spatial orientation, and the surface ornamentation. Data were drawn from documentary and literature sources that describe these features, including scholarly studies of Dayak vernacular architecture, documentation of the rumah betang and rumah radakng, and the established literature on the building physics of tropical stilt houses. These sources were selected because they provide stable, verifiable descriptions of the building and because they allow the indigenous practices to relate to recognised scientific principles.

Data Collection

Data were collected through literature study and documentation analysis. The procedure involved gathering descriptive accounts of each architectural element, recording the practical reasoning that local builders attach to it, and noting the environmental function that the element serves. Information about materials, dimensions, and construction techniques was compiled and organised by architectural component so that each component could be analysed as a discrete unit of indigenous knowledge.

Data Analysis

Analysis proceeded in three stages adapted from the ethnoscience reconstruction model. In the first stage, the indigenous knowledge embedded in each architectural element was identified and stated in the terms used by the community, such as raising the floor to avoid flood and damp or selecting ironwood for posts that meet water and soil. In the second stage, this indigenous knowledge was reconstructed into scientific knowledge by relating each practice to its underlying scientific principle, for example by explaining the elevated floor through pressure, fluid statics, and convective airflow. In the third stage, the reconstructed concepts were mapped against topics in the secondary science curriculum and against suitable learning models, so that each concept could be positioned as a usable learning resource.

RESULTS AND DISCUSSION

Indigenous Science Embedded in Dayak Vernacular Architecture

The Dayak longhouse presents a coherent system of design choices, each shaped by long experience of living within a tropical riverine environment. The most striking feature is its elevation. The building stands on tall wooden posts that lift the living floor several metres above the ground. Local accounts explain this elevation as protection against seasonal floods, ground moisture, wild animals, and, in earlier times, sudden attack. The space beneath the floor also keeps the interior cooler and drier, since air moves freely under the raised platform.

A second feature is the careful selection of building material. Posts and primary structural members are made from ironwood, known locally as ulin or belian, a timber prized for its extreme density and its resistance to rot, insects, and water. Builders reserve this material for the parts of the house that bear the greatest load and that meet soil and moisture, which reflects a practical understanding of durability that has been confirmed across generations of use.

A third feature is the form of the roof. The longhouse carries a steep gabled roof with deep overhangs. The steep pitch sheds the heavy rain of the equatorial climate rapidly, while the overhanging eaves shade the walls and openings from direct sun and driving rain. A fourth feature is the joinery. Traditional builders connect timbers through mortise and tenon fittings secured with wooden pegs rather than relying on metal nails, which produces joints that flex slightly under load and movement instead of fracturing. A fifth feature is the management of air and light. Slatted floors, openings, and the elevated form together encourage the movement of air through and beneath the building, which counters heat and humidity. Finally, the house is sited and oriented in relation to the river and the path of the sun, and its surfaces are decorated with carvings and natural pigments in red, white, black, and yellow that carry both protective and symbolic functions.

Reconstruction into Scientific Concepts

When the practical reasoning behind each element is examined through scientific principles, the longhouse reveals a dense network of concepts that span several science subjects. The reconstruction is summarised in Table 1, which presents each architectural element together with the indigenous knowledge it carries, the reconstructed scientific concept, and the relevant science topic.

Table 1. Reconstruction of Dayak architectural knowledge into scientific concepts

Architectural element	Indigenous knowledge / practice	Reconstructed scientific concept	Science topic
Elevated stilt structure (3 to 5 m posts)	Raising the living floor to avoid floods, ground damp, and animals, and to let air pass beneath the house	Pressure ($P = F/A$) and load transfer through posts; fluid statics and flood hydrology; structural equilibrium and centre of gravity; convective airflow beneath the floor	Physics: pressure, fluids, equilibrium, heat transfer
Ironwood (ulin / belian) posts and frame	Choosing dense, rot-resistant timber for parts that bear heavy load and meet water and soil	Material density and mechanical strength; natural durability from lignin and wood extractives; biological resistance to decay organisms	Physics and chemistry: density, materials; biology: wood anatomy and decay
Steep gable roof with deep eaves	Shedding heavy tropical rain quickly and shading the walls from sun and rain	Gravity-driven runoff and the component of weight along an inclined plane; force vectors; solar shading geometry	Physics: forces on inclined planes, vectors; optics and solar geometry
Mortise and tenon joinery with wooden pegs	Joining timbers so that they flex under movement instead of breaking, with little use of nails	Tension and compression in structures; elasticity; dissipation of energy; flexibility underground movement	Physics: elasticity, forces, structures
Cross-ventilation, slatted floors, and openings	Keeping the interior cool and dry in a hot and humid climate	Convection and the stack effect; conduction and insulation through wood; evaporation and humidity	Physics: heat transfer, fluids, thermodynamics

Architectural element	Indigenous knowledge / practice	Reconstructed scientific concept	Science topic
		control; air-pressure differences	
Riverside siting and solar orientation	Placing and orienting the long building for water access, transport, breeze, and daylight	Settlement and river ecology; surface hydrology; passive solar orientation and energy efficiency	Earth and environmental science; ecology
Carvings and natural pigments (red, white, black, yellow)	Colouring and protecting timber surfaces with locally sourced materials	Pigments and natural dyes as chemical colorants; absorption and reflection of light; surface protection	Chemistry: pigments and dyes; physics: light and colour

Table 1 shows that a single building can support a wide span of scientific content. The elevated structure alone connects to several concepts at once. The transfer of the building load through slender posts illustrates pressure as force distributed over area, since a heavy structure must rest on supports that can carry the load without sinking into soft riverbank soil. The same elevation introduces fluid statics and flood hydrology, because lifting the floor above the expected water level keeps the dwelling dry when rivers rise. The open space beneath the floor introduces convection, since cooler air flows under and around the building and carries heat away. The stability of a tall structure on posts further invites discussion of equilibrium and centre of gravity.

The choice of ironwood is equally instructive. Its performance can be explained through density and mechanical strength, which determine how much load a post can bear before failing. Its long life in contact with water and soil can be traced to the lignin content and natural extractives that resist fungal and insect attack, which links the practice to both chemistry and the biology of wood decay. In this way a single material choice reaches across more than one science subject.

The roof, the joinery, and the ventilation system extend the range further. The steep pitch of the roof can be analysed through the resolution of the weight of rainwater into components along an inclined surface, which connects directly to the study of forces and vectors. The flexible wooden joints illustrate tension, compression, and elasticity, and they show how a structure can dissipate energy and survive ground movement by bending rather than snapping. The ventilation arrangement demonstrates the three modes of heat transfer together with the stack effect, in which warm air rises and escapes while cooler air is drawn in from below. These mechanisms have been documented in studies of tropical stilt houses, which confirm that the elevated and ventilated form produces a more comfortable interior than a comparable structure placed directly on the ground.

Dayak Architecture as a Contextual Science Learning Resource

The reconstructed concepts can be organised into learning resources that fit the secondary science curriculum. The stilt structure and its physics of pressure, fluids, and heat transfer suit topics on force, pressure, and energy at the junior secondary level, and they extend naturally to fluid statics and thermodynamics at the senior secondary level. The material science of ironwood connects to topics on the properties of matter and on the structure and function of living tissue. The roof and joinery support topics on forces, vectors, and the elasticity of materials, while the ventilation system supports topics on heat and temperature. The siting of the longhouse links to earth and environmental science through hydrology and ecology.

These resources are well suited to active learning models. Project-based learning allows students to investigate why the longhouse stands on stilts by building and testing simple models,

measuring how elevation changes airflow and temperature, or comparing the load behaviour of different post arrangements. Inquiry and discovery learning invite students to pose questions about why ironwood resists decay or why a steep roof sheds rain more quickly, and then to design investigations that answer them. Because the building is familiar and visible to many learners in Kalimantan, it provides an authentic anchor for these investigations, which raises engagement and supports the development of scientific literacy and science process skills, consistent with earlier ethnoscience research.

The resource also carries value beyond cognitive learning. Studying the longhouse strengthens cultural literacy, since students examine the knowledge of their own communities and see it treated as a legitimate object of scientific reasoning. It supports conservation values, since the building demonstrates a sustainable response to climate that relies on local materials and passive design. It aligns with the Pancasila Student Profile, since the communal construction of the longhouse models cooperation and shared responsibility while its careful use of resources models stewardship of the environment. In this way the resource integrates scientific competence with character formation, which is a central aim of current curriculum policy.

Discussion

The findings demonstrate that Dayak vernacular architecture embodies a sophisticated body of indigenous scientific knowledge that has been accumulated through long-term adaptation to the environmental conditions of tropical riverine ecosystems. The elevated stilt structure, the use of ironwood, the steep roof design, and the natural ventilation system are not merely cultural expressions but represent practical solutions developed through continuous observation and interaction with the surrounding environment. This finding supports the view of ethnoscience as a form of empirical knowledge generated within local communities and refined across generations (Sturtevant, 1964; Rist & Dahdouh-Guebas, 2006). The architectural features identified in this study illustrate how local communities apply principles that correspond closely to modern scientific concepts, even though these principles are not formally articulated using scientific terminology. Such evidence reinforces the argument that indigenous knowledge systems contain valuable scientific reasoning that deserves recognition within science education.

The reconstruction process further reveals that a single cultural artifact can provide access to multiple interdisciplinary scientific concepts spanning physics, chemistry, biology, and earth science. This finding extends previous ethnoscience studies that have primarily focused on local food, medicinal plants, and traditional agricultural practices (Dewi et al., 2019; Widiyatmoko et al., 2015). Unlike many ethnoscience resources that are limited to a single scientific domain, the Dayak longhouse offers an integrated context through which students can simultaneously explore concepts of pressure, heat transfer, material properties, ecological adaptation, and environmental sustainability. From the perspective of the Model of Educational Reconstruction (Duit et al., 2005), such integration provides opportunities to bridge learners' everyday experiences with formal scientific explanations. Consequently, vernacular architecture may serve as a particularly effective medium for promoting conceptual coherence and helping students understand the interconnected nature of scientific phenomena.

From an educational perspective, the findings have important implications for contextual science learning under the Merdeka Curriculum framework. The reconstructed scientific concepts align closely with inquiry-based and project-based learning approaches, allowing students to investigate scientific principles through culturally meaningful contexts. This supports previous studies indicating that ethnoscience-based learning can improve student engagement, scientific literacy, and positive attitudes toward science (Fasasi, 2017; Rahmawati et al., 2019). Furthermore, integrating Dayak architectural knowledge into science instruction contributes not only to cognitive learning outcomes but also to the development of cultural literacy and environmental awareness. By examining scientific principles embedded in their own cultural heritage, students may develop a

stronger sense of identity while simultaneously appreciating the relevance of science to everyday life. Therefore, the incorporation of vernacular architecture into science education represents a promising strategy for achieving the dual objectives of scientific competence and cultural preservation.

Implications and Challenges

The findings imply that teachers in West Kalimantan and across the island can draw on a visible and meaningful local artefact to make abstract science concrete. The longhouse offers a coherent context that can frame an entire unit rather than a single isolated example, which helps students perceive science as connected and relevant. At the same time, several challenges deserve attention. Teachers need support in reconstructing local knowledge accurately, since superficial connections can distort both the culture and the science. Care must be taken to represent Dayak knowledge respectfully and in collaboration with community members, so that the culture is honoured rather than reduced to a teaching device. Empirical classroom studies are also needed, since the present study establishes the conceptual potential of the resource but does not yet measure its effect on learning. Future research should develop and test teaching materials based on this reconstruction and should examine their impact on scientific literacy, cultural literacy, and conservation attitudes.

CONCLUSION

This study set out to identify the indigenous science embedded in the vernacular architecture of Dayak traditional houses and to reconstruct it into contextual science learning resources. The analysis shows that the Dayak longhouse is a coherent and concept-rich artefact. Its elevated stilt structure embodies pressure, fluid statics, flood hydrology, structural equilibrium, and convection. Its ironwood frame embodies material density, mechanical strength, and biological decay resistance. Its steep roof, flexible joinery, ventilation system, siting, and natural pigments embody, respectively, inclined-plane forces, elasticity and energy dissipation, heat transfer and the stack effect, river and settlement ecology, and the chemistry of pigments. These reconstructed concepts map onto topics in physics, chemistry, biology, and earth science across the secondary curriculum, and they fit project-based and inquiry learning that strengthens scientific literacy, cultural literacy, and the values of the Pancasila Student Profile. The Dayak longhouse therefore stands as a strong and underused contextual learning resource that joins scientific reasoning to cultural identity and to the conservation of a sustainable architectural heritage. Further work should turn this conceptual foundation into tested teaching materials developed together with Dayak communities.

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