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[Research Article]

REDESIGNING CONTEXT-BASED PHYSICS INSTRUCTION USING THE STEM APPROACH TO THE MANDI KASAI TRADITION OF LUBUKLINGGAU AND ITS IMPLICATIONS FOR LEARNING ASSESSMENT

Yaspin Yolanda[1], Bambang Heriyadi[2], Pinta Murni[3], and Muhammad Naswir[4]

[1234]Doctoral Program in Science Education, University of Jambi, Indonesia
E-mail: yaspinyolanda@unpari.ac.id

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ABSTRACT

The problem addressed in this study lies in the suboptimal utilization of ethnoscience as a learning resource, which has prevented the scientific reconstruction of local traditions. Additionally, limitations in contextual STEM assessment instruments mean that teachers lack adequate guidance for developing physics instruction that is both challenging and relevant to local cultural contexts. This study aims to: (a) analyze the physics concepts embodied in the Mandi Kasai tradition; (b) map the relationships between these concepts within the STEM (Science, Technology, Engineering, and Mathematics) framework; and (c) develop context-based learning assessments aligned with local cultural heritage. A qualitative research methodology with an ethnographic approach was employed. Data were gathered through observations, interviews with 3 physics teachers, 3 customary community leaders, and 4 community members who practice the Mandi Kasai tradition, alongside documentation and literature review. Data analysis followed three stages: data reduction, data presentation, and conclusion drawing. The results reveal that the Mandi Kasai tradition encompasses a range of physics concepts, including heat, heat transfer, changes in the state of matter, and fluid mechanics all of which can be integrated within the STEM framework. The context-based assessment instrument developed in this study obtained an expert validation score of 93.5%, placing it in the highly valid category, confirming its suitability for use in physics instruction rooted in local culture. Future research is recommended to develop ethnoscience-based physics learning modules that integrate the Mandi Kasai context using the STEM approach.

Keywords: Assessment, Contextual, Ethnoscience. Mandi Kasai Tradition, STEM

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1. INTRODUCTION

Physics education in Indonesia still faces a major challenge in bridging abstract concepts with real-life experiences. As a result, students tend to understand physics merely as a set of procedures without being able to apply it in concrete situations. This situation leads to low levels of critical thinking, problem-solving skills, and science literacy. This is also emphasized in the PISA framework by the OECD(Osborne et al., 2025), which assesses individuals' ability to apply scientific knowledge in relevant ways in daily life(Berkes, 2010).

The mandi kasai and Betangas traditions in Lubuklinggau, for example, embody various physics concepts such as heat transfer, changes in the state of matter, and basic principles of thermodynamics; however, to date, they have not been systematically studied or utilized within a STEM-based learning framework(Bin et al., 2025). On the other hand, local wisdom, as a reflection of community culture(Rudnev et al., 2024), holds various practices rich in scientific concepts(Chibuye & Sen, 2024; Govender et al., 2025). Wedding traditions such as the mandi kasai and Betangas in Lubuklinggau are concrete examples of cultural practices that incorporate physical phenomena, such as heat transfer, changes in the state of matter, vapor pressure, and simple thermodynamic principles. Nevertheless, this potential has not yet been fully utilized in the development of ethnoscience-based science learning integrated with the STEM approach(Gusman & Yulina, 2023; Parviz, 2024).

Recent developments in science education research indicate that the ethnoscience approach is increasingly recognized as an effective strategy for linking learning to local cultural(Chibuye & Sen, 2024; Mindia et al., 2025). Various studies reveal that ethnoscience can improve conceptual understanding, strengthen science literacy, and foster an appreciative attitude toward culture. On the other hand, the STEM approach has also been extensively studied and proven to contribute to the development of 21st-century skills, such as critical thinking(Zakiyah, 2022), creativity(Nurhasnah et al., 2022), collaboration(Fitri & Asrizal, 2023), and problem-solving through contextual learning(Putri et al., 2024).

Furthermore, recent research trends point toward the integration of ethnoscience and STEM as an innovative approach to context-based learning(Maryna et al., 2025; Taqiyyah et al., 2023). Several studies have begun to explore this integration in various aspects of life, such as local crafts, traditional games, and even the daily activities of communities(Snively & Corsiglia, 1998; Trudgett et al., 2025). The results indicate that the ethnoscience-STEM approach effectively connects scientific concepts with students' cultural realities, thereby making learning more relevant and meaningful(Prihatiningtyas et al., 2025; Shidiq et al., 2023; Zakiyah, 2022). However, the implementation of this integration remains largely general in nature and has not yet deeply examined the mapping of interdisciplinary STEM concepts within specific cultural practices(Govender et al., 2025; Lohakan & Seetao, 2024).

Several previous studies have shown that the integration of ethnoscience and STEM has the potential to improve science literacy(Ardianti & Raida, 2022), 21st-century skills(Sanova & Malik, 2023), and the relevance of learning to students' lives(Chibuye & Sen, 2024). However, existing studies remain general in nature and have not yet thoroughly mapped the interdisciplinary connections within STEM in specific cultural practices(Otto et al., 2025; Widiyatmoko et al., 2024), particularly within the context of wedding traditions. Additionally, there is a significant gap in the form of the lack of a systematic learning reconstruction model and contextual assessment instruments capable of authentically measuring science literacy achievements based on local culture(Yolanda & Pribadi, 2026).

Therefore, this study offers a solution through the reconstruction of STEM-based physics learning within an ethnoscience context, by mapping physics concepts within the Mandi Kasai and Betangas traditions and developing contextual assessments aligned with global science literacy requirements. The objectives of this study are to (a) analyze physics concepts within the Mandi Kasai tradition, (b) map their relevance within the STEM framework, and (c) reconstruct culturally grounded contextual learning assessments, thereby strengthening science literacy and fostering more relevant, authentic, and meaningful physics learning.

Based on this review, the following research gaps can be identified: (1) the limited number of studies that specifically integrate a STEM approach into ethnoscience studies based on local traditions(Anderson et al., 2022; Fajriyani, 2023) (2) a lack of research that systematically explores physics concepts within cultural practices, particularly in wedding traditions such as mandi kasai and Betangas; and (3) the absence of a comprehensive mapping that links elements of science, technology, engineering, and mathematics within a cohesive ethnoscience analytical framework.

Based on this, this study offers a novel approach by integrating STEM principles into ethnoscience research to identify and analyze the physics concepts embedded in the Mandi Kasai and Betangas traditions. This study not only focuses on identifying physics concepts but also examines their relationship with traditional technology, simple engineering principles, and mathematical representations within the context of local culture. Thus, the results of this study are expected to enrich STEM-based ethnoscience studies and serve as a foundation for the development of contextual, innovative science learning rooted in local wisdom.

The objectives of this study are (a) to analyze the physics concepts embedded in the Mandi Kasai tradition, (b) to map the conceptual connections within the STEM (Science, Technology, Engineering, Mathematics) framework as reflected in the cultural practices of Mandi Kasai and Betangas, and (c) to develop context-based learning assessments relevant to local culture. Thus, this study is expected to contribute to the development of physics learning that is more meaningful, contextual, and based on local wisdom.

2. METHOD

This study employs a qualitative research design with an ethnographic approach, aiming to uncover the scientific significance underlying the cultural practices of the community. The research was conducted in Lubuklinggau, focusing on the Mandi Kasai and Betangas wedding traditions. Research subjects include traditional leaders, tradition practitioners, and community members directly involved in the processions, as well as physics teachers to analyze physics concepts within the traditions, reconstruct assessments, and map STEM learning. Data collection techniques include observation, in-depth interviews, documentation, and literature review(Miles & Huberman, 1994). Participatory observation was used to directly observe the stages of the processions and the phenomena occurring, while interviews were conducted to explore local understandings regarding the meanings and practices of the traditions. Documentation in the form of photos, videos, and field notes was used to strengthen the research data(Creswell, 2020; Wallwey & Kajfez, 2023)

Table 1. Data sources, instruments, and data analysis.

Objective	Data Source	Instruments	Data Analysis
1. Analyzing physics concepts in the Mandi Kasai tradition	1. Traditional Leaders, 2. Communities Practicing Traditions, 3. Photos and Videos, 4. Scholarly References	1. Observation guidelines, 2. Guidelines in-depth interviews, 3. documentation	1. Thematic Analysis (Identification of Physical Phenomena), 2. Data Reduction, 3. Categorization of Physical Concepts, Source Triangulation
2. Mapping conceptual connections within the STEM framework	1. Data from the analysis of physics concepts, 2. STEM literature,	1. STEM analysis sheet, 2. Expert validation guidelines,	1. Content analysis, 2. Concept mapping, 3. Categorization of STEM elements,

Objective	Data Source	Instruments	Data Analysis
	3. Expert validation in collaboration with physics teachers	3. STEM mapping matrix	4. Analysis of the expert validation sheet
3. Reconstructing Context-Based Learning Assessments	1. Physics teachers, students, 2. results of concept analysis and STEM mapping, 3. curriculum documents	1. Interview guidelines, 2. Validation guidelines, 3. Assessment questions, 4. FGD (Focus Group Discussion)	1. Needs assessment, 2. Thematic analysis and design, 3. Instrument validation (expert judgment), 4. Validity testing through triangulation and member checking

Data analysis in this study was conducted using a descriptive qualitative approach through the stages of data reduction, data presentation, and drawing conclusions. The data obtained were analyzed to identify the physics concepts contained in the mandi kasai and betangas traditions, such as heat, temperature, changes in the state of matter, and pressure, and were then scientifically interpreted by relating them to relevant principles of physics. Furthermore, the data were categorized based on the occurrence of physics concepts at each stage of the processions, thereby providing a systematic overview of the relationship between cultural practices and scientific concepts(Wallwey & Kajfez, 2023).

The next step is to map concepts within a STEM framework that integrates aspects of science, traditional technology, simple engineering, and mathematical representations within these cultural practices. Based on the results of this mapping, a contextual learning assessment relevant to the local culture is reconstructed, designed to measure conceptual understanding, critical thinking skills, and the connection between science and real life. Data validity is ensured through triangulation of sources, techniques, and time by comparing the results of observations, interviews, and documentation, and is reinforced through member checks and audit trails to ensure the accuracy and traceability of the research process, thereby producing a comprehensive picture of the value of ethnoscience in the mandi kasai tradition and its connection to physics concepts as the basis for the development of contextual learning(Creswell & Creswell, 2018; Iwano & Tsuda, 2024).

3. RESULT AND DISCUSSION

The mandi kasai tradition is a form of local wisdom that has long existed and evolved within the community of Lubuklinggau City, South Sumatra. This tradition has been passed down from generation to generation as an important part of the traditional wedding customs, particularly regarding the purification of the bride and groom before the reception. Specifically, the mandi kasai ritual is performed in the Kelingi River as a symbol of physical and spiritual cleansing. During the ceremony, the bride and groom are escorted from the bride’s home to the river on a litter carried by family members, primarily siblings from both sides.

3.1 *Analyze physics concepts embedded in the Mandi Kasai tradition*.

This procession holds not only symbolic significance but also reflects the strong sense of family participation and unity in upholding this tradition. The traditional mandi kasai ceremony begins with a preparatory phase involving a steam bath ritual, or “betangas” a process of warming the body using water infused with spices, covered with a pandan mat to keep the steam focused on the bride and groom. Next, the couple dons traditional attire and is escorted to the Kelingi River, the site of the main mandi kasai ritual. At this stage, water is poured over them by close family members as a symbol of self-purification.

After the bathing procession is complete, the couple’s bodies are dried naturally or with the aid of cloth, and then both are escorted back to the bride’s home to continue the series of wedding reception events. This entire sequence represents a fusion of cultural values, symbolic meanings, and the community's rich, meaningful empirical practices.

Based on Figure 1 above, the wedding procession in the Mandi Kasai tradition incorporates physical concepts outlined in Table 2, based on the results of a focus group discussion involving physics teachers.

Figure 1. The wedding procession using a palanquin.

Table 2. Results of Focus Group Discussions, Interviews, and Literature Reviews on the Kasai and Betangas Bathing Traditions,

Process	Scientific Explanation of a Physics Concept
1. A wedding procession using a palanquin. 2. The bride and groom are lifted and carried by several people	**Physics Concepts: Dynamics (force, work, and energy)** The activity of lifting and moving the bride and groom using a litter in the mandi kasai tradition can be explained through concepts of physics, particularly in the field of mechanics. This process involves forces exerted by several people to lift the load consisting of the bride's body and the palanquin. The forces exerted must be sufficient to overcome the gravitational force acting on the system, thereby achieving a state of equilibrium during both the lifting and the movement. Additionally, when the palanquin is moved from one location to another, work is performed defined as the product of the force exerted and the displacement that occurs.
1. Carrying the stretcher by family members. 2. Distributing the load among several people	**Physics Concepts: Newton's Laws and the Equilibrium of Objects.** The carrying of the palanquin by family members in the Mandi Kasai tradition reflects the application of Newton's laws and the principle of equilibrium. The weight of the bride and the palanquin is distributed evenly among several people so that the forces acting on them are balanced. In accordance with Newton's laws, specifically the condition of equilibrium (where the resultant force equals zero), the palanquin can be lifted and carried steadily without unwanted acceleration. This distribution of weight also helps maintain the stability of the system, ensuring the palanquin remains in a balanced position throughout the carrying process.
The procession of the bride and groom to the river and back home	**Physics Concepts: Work and Energi** The wedding procession in the Betangas tradition of Lubuklinggau illustrates the close connection between culture and physics concepts, particularly work and energy. When the litter carrying the bride and groom is lifted and moved, the bearers perform work by applying a force that results in displacement. At the same time, the raised position of the palanquin indicates the presence of gravitational potential energy, while the chemical energy within the bearers' bodies is converted into mechanical energy to sustain the motion. Some energy is also dissipated as heat due to muscle activity and interaction with the environment. Coordination of

Process	Scientific Explanation of a Physics Concept
	movement and balance of steps are important factors in energy efficiency, so this procession is not only symbolic but also reflects the practical application of the principles of work and the conservation of energy in daily life.
1. Steam bath (betangas) with hot water; 2. the body is exposed to hot steam from boiling water	**Physics Concepts: Heat & Heat Transfer** The steam bath (betangas) process in the Kasai bathing tradition is closely related to the concepts of heat and heat transfer through the mechanisms of convection and conduction. The hot steam produced from boiling water rises and envelops the bride's body, resulting in heat transfer via convection—that is, heat carried by the flow of a fluid (steam). When the hot steam comes into direct contact with the skin's surface, heat transfer occurs via conduction—that is, the transfer of heat through direct contact between the steam and the body. The combination of these two processes causes the body temperature to rise gradually, providing a warming and relaxing effect, and demonstrating how thermal energy transfers from a heat source to the body in everyday life.
1. The use of pandan mats during the betangas ceremony 2. Hot steam is trapped around the body	**Physics Concepts: Insulators and Conductors** The use of pandan mats in the steam bath (betangas) process within the Kasai bathing tradition relates to the concepts of insulators and conductors in physics. The pandan mat functions as a thermal insulator—a material that impedes heat transfer—so that hot steam remains trapped around the bride's body and the temperature is maintained. Unlike conductive materials that easily transfer heat, the pandan mat actually slows the release of heat into the environment. Thus, the use of this mat demonstrates a simple application of the concept of thermal insulation to maintain temperature, allowing the betangas process to proceed more effectively.
Heating water to produce steam	**Physics Concept: Changes of State of Matter.** The herbal water used in the steaming process of the traditional Kasai bath demonstrates the concept of changes of state of matter. When water is heated, the thermal energy supplied causes the water molecules to move faster, causing it to change from a liquid to a gaseous state (vapor). This process is called evaporation or the phase change from liquid to gas, which is one form of a change in the state of matter resulting from the absorption of heat.
Drying off after a shower	**Physics Concept: Changes of State.** The drying of the body after bathing in the Kasai bathing tradition is related to the concept of changes of state, specifically the process of evaporation. Water on the skin's surface absorbs heat from the surrounding environment, causing it to change from a liquid to a gas (vapor). This process occurs naturally due to the presence of thermal energy, which causes water particles to move faster and eventually leave the skin's surface.

Based on the results of focus group discussions, interviews, and literature reviews, the series of rituals in the Mandi Kasai tradition demonstrates a strong connection to concepts in physics, particularly particle dynamics and Newton's laws. The procession of the bride and groom on a palanquin represents the concepts of force, work, and energy, as the bearers apply force to counteract gravity and perform work while moving the palanquin from one location to another. The even distribution of the load reflects the principle of equilibrium of forces, allowing the palanquin to move stably. Additionally, the use of cloth to dry the bride's body demonstrates the concept of capillarity through the process of water absorption by the fabric fibers. These findings confirm that local cultural practices contain contextual and practical principles of physics applicable to daily life (Mansour et al., 2025; Yolanda, 2020; Yolanda et al., 2025).

In addition to the main ritual, the mandi kasai tradition also includes betangas, a form of body care involving a steam bath using water infused with herbs such as pandan leaves, lemongrass, and cinnamon. This practice not only holds symbolic significance as a form of self-purification but also incorporates ethno-scientific concepts such as heat transfer via convection and conduction, the phase change of a substance from liquid to gas, and the physiological effects of heat on the body. The use of a pandan mat as a cover serves as a heat insulator, while the process of water evaporation reflects energy transformation within the system. Overall, the mandi kasai and betangas traditions represent the integration of cultural values and scientific concepts, thus having the potential to serve as a source of contextual and meaningful physics learning.

3.2 Map the connections between these concepts within the STEM.

The integration of STEM into the mandi kasai tradition represents the convergence of science, technology, engineering, and mathematics concepts, which are contextualized within the community's cultural practices. This approach not only treats culture as an object of study but also as an authentic source of learning through activities such as context-based learning, presentations of mandi kasai analysis results, and reflective discussions that encourage active student engagement. Through this process, students are expected to develop critical and integrative thinking skills, produce STEM-based products or projects(Chibuye & Sen, 2024; Frawley et al., 2017; Pratama & Jumadi, 2023), and foster an awareness of the importance of synergy between science and local wisdom values in daily life(Nurhasnah et al., 2022; Rumadan et al., 2023; Sanova & Malik, 2023). The mapping of the STEM framework contained within the Mandi Kasai cultural practice is outlined in tables 3 and 4.

The integration of STEM into the betangas tradition demonstrates the convergence of concepts such as heat, the application of traditional technology, steam system design, and contextual measurement within cultural practices. Through this approach, betangas is understood not only as a body care ritual but also as an authentic medium for ethoscience education. Its implementation can be carried out through ethnoscience-based projects, such as the creation of betangas miniatures, followed by the presentation of scientific analysis results and reflective discussions that link cultural values with scientific concepts. This process encourages students to think critically and integratively, produce STEM-based products or projects, and foster an awareness of the importance of the connection between science and local wisdom in daily life(Ainur et al., 2025; Pratama & Jumadi, 2023; Rudnev et al., 2024).

Table 3. STEM Framework, Physics Concepts, and Learning Outcomes of the Betangas Tradition.

STEM Components	Concepts of Physics in the Betangas Tradition	Learning Activities (Contextual)	Student Learning Outcomes
Science (physics concept)	a) Heat transfer (convection in steam, conduction on the skin) b) Phase change of a substance (liquid → gas) c) Evaporation of essential oils from spices d) The effect of heat on the body (improving blood circulation) e) Thermal properties of natural materials	a) Observing the process of steam formation from boiling water; b) Identifying the type of heat transfer; c) Analyzing the role of spices in producing aroma and physiological effects	a) Be able to explain the concepts of heat and changes in the state of matter b) Relate cultural phenomena to concepts in physics and chemistry c) Write a scientific report based on observations
Technology	a) Traditional betangas equipment (water container, heat source, bench, cover) b) Boiling techniques and the use of steam c) The use of natural	a) Identify the tools and materials used in betangas b) Compare traditional and modern technologies (modern spa)	a) Be able to explain the functions of tools and technologies within a cultural tradition b) Develop ideas for innovative, culture-based simple tools

STEM Components	Concepts of Physics in the Betangas Tradition	Learning Activities (Contextual)	Student Learning Outcomes
	ingredients in traditional therapy	c) Simulate the use of simple tools	c) Write a description of a product or tool
Engineering	a) Steam system design (heat source positioned below) b) Enclosing the space with fabric to retain heat c) Using mats as heat insulators d) Efficient use of thermal energy	a) Design a simple model of a steam system; b) Create a flowchart of the steam process; c) Discuss thermal efficiency and safety	a) Able to create simple system designs (models/diagrams) b) Demonstrate problem-solving skills c) Understand simple engineering principles in everyday life
Mathematics	a) Measurement of water and steam temperature b) Estimation of heating time and steam processing time c) Calculation of spice quantities d) Water volume and container capacity	a) Measuring the temperature and processing time b) Calculating the spice ratio c) Estimating the amount of water needed	a) Be able to calculate temperature, time, and volume b) Apply mathematical concepts in real-world contexts c) Present data in tables or graphs
STEM Integration	The integration of thermal concepts, traditional technology, steam system design, and measurement in betangas practice	a) Ethnoscience-based project (making miniature betangas) b) Presentation of scientific analysis results c) Reflective discussion on cultural values and science	a) Able to think critically and holistically b) Produce STEM-based products or projects c) Demonstrate an awareness of cultural and scientific values

3.3 Develop context-based learning assessments relevant to the local culture.

Integrating local traditions such as mandi kasai and betangas into learning assessments can be achieved by using them as authentic contexts to measure students' conceptual understanding as well as their higher-order thinking skills(Govender et al., 2025; Lohakan & Seetao, 2024). In practice, teachers can design ethnophysics-based questions or tasks that link cultural activities such as wedding processions using a palanquin or the water heating process in betangas to scientific concepts like work, energy, heat, and heat transfer. Through this approach, students not only solve problems mathematically but are also asked to analyze real-world phenomena in their environment, explain cause-and-effect relationships, and evaluate energy efficiency in these practices(Anderson et al., 2022; Fitri & Asrizal, 2023; Mansour et al., 2025). Additionally, assessments can be developed in the form of projects, case studies, or worksheets that encourage direct observation, interviews, and reflection on the cultural values embedded within them. Thus, assessments do not merely measure cognitive learning outcomes but also foster scientific literacy, contextual skills, and an appreciation for local wisdom as part of meaningful learning(Aguayo et al., 2023; Putri et al., 2024; Sanova & Malik, 2023), as shown in Table 4

Table 4. Results of the Expert Assessment Validation.

Question	Evaluated Aspects	Validation Results	Category	Suggestions for Improvement
Question 1 (Heat Transfer - Convection & Conduction)	Content appropriateness, cultural context, higher-order thinking skills	Highly relevant, contextual, and encourages analysis	Highly Valid	Add an illustration of the betangas process to make it more concrete
Question 2 (Insulators & Conductors)	Basic concepts of heat and their applications	Very relevant to real life	Highly Valid	Please clarify the difference between the terms "insulator" and "conductor" in the given stimulus.
Question 3 (Particle Equilibrium)	Accuracy of the concepts of force and torque	Okay, requires analytical thinking	Valid	Add an image or sketch of the stretcher's position to aid visualization
Question 4 (Work and Energy)	The relationship between the concepts of work, energy, and power	Very practical and context-specific	Highly Valid	Specify the units and direction of the force in the problem
Question 5 (Capillarity)	Accuracy of concepts and calculations	Okay, integrating microscopic concepts	Valid	Scientific notation needs to be clarified so as not to confuse students
Question 6 (Heat Transfer - Conduction)	Analisis matematis dan konsep	Very good, quantitative analysis	Highly Valid	Add instructions on how to use the formula for students
Question 7 (Changes in the State of Matter)	A Comprehensive Overview of the Concepts of Heat and Phase Changes	Very comprehensive	Highly Valid	There are quite a few questions; they can be divided into two categories
Question 8 (Insulators & Conductors)	Conceptualization and analysis	Appropriate and consistent with the context	Valid	Avoid repeating the context; vary the problem situations

Table 5. Integration local wisdom into the Learning Assessment.

Question 1. The Concept of Heat Transfer in Physics

In the Kasai bathing tradition, the bride and groom undergo the betangas (steam bath) ritual by sitting over boiling water that produces hot steam. The steam rises and envelops their bodies, coming into direct contact with their skin, leaving them feeling warm and relaxed.

Question:

1. Explain how heat transfer by convection occurs during the betangas ceremony! and
2. Explain how heat transfer by conduction occurs when steam touches the bride's skin!
3. In your opinion, why does the bride's body warm up gradually rather than suddenly?
4. Relate this to the mechanism of heat transfer! and
5. Give another example from everyday life that demonstrates convection and one example of conduction!

Question 2. Physics Concepts of Heat Transfer

In the Kasai bathing tradition, the betangas process uses a pandan mat to cover the bride's body so that the hot steam remains trapped inside. Pandan mats are known to be poor conductors of heat.

Questions:

1. Explain why pandan mats can be classified as thermal insulators in the betangas process!
2. What would happen if the pandan mat were replaced with a metal material?
3. Explain based on the concepts of conductors and heat transfer!
4. Why does the use of a pandan mat make the betangas process more effective in keeping the body warm?
5. Name two examples of objects in everyday life that function as insulators and conductors, and explain their functions!

Question 3: Physics Concepts of Particle Equilibrium

During the wedding procession, a uniquely shaped palanquin (as shown in the figure) is carried by four bearers (two in front and two in back). The total mass of the palanquin and the bride is 120 kg. The length of the palanquin's support poles is 4 meters. The center of mass is located 1.5 meters from the front end of the palanquin. Assume the system is in equilibrium when lifted steadily.

Question:

1. Determine the forces exerted by the front and rear bearers to keep the stretcher balanced!
2. Write down and explain the equations $\sum F = 0$ and $\sum \tau = 0$ in this case!
3. If one of the rear bearers reduces their lifting force, what will happen to the stretcher's balance? Explain in terms of physics! and
4. How does the position of the center of mass affect the distribution of forces on the stretcher bearers?
5. Analyze how the shape of the stretcher (which is asymmetrical) can affect the balance of the system!

Question 4: The Concepts of Work and Energy in Physics

In the mandi kasai procession, the bride is carried on a litter by four bearers to a river 120 meters away. The total weight of the bride and the litter is 80 kg. During the journey, the palanquin is carried at an average height of 1.2 meters above the ground. The journey takes place on flat ground, but there are resistive forces in the form of air resistance and the carriers' fatigue, equivalent to a force of 40 N.

Question:

1. Calculate the total work done by the stretcher-bearers during the journey!
2. What is the gravitational potential energy of the stretcher when it is lifted?
3. If the journey takes 2 minutes, what is the average power exerted by the stretcher-bearers?
4. Explain the relationship between the concepts of work and energy in the context of this tradition!
5. Analyze how cultural factors (number of bearers, lifting technique, and walking rhythm) can influence the amount of work and energy expended!

Question 5: The Concept of Capillary Action in Physics

In the mandi kasai ritual, after the bride has been bathed, her body is dried using a traditional cloth. This cloth has fine fibers that can quickly absorb water through capillary action. It is known that: Average pore radius (gap) of the fabric = 2×10^{-52} m, Surface tension of water = 0.072 N/m, Contact angle between water and fabric fibers = 0° (complete absorption), Density of water = 1000 kg/m^3 and Acceleration due to gravity = 10 m/s^2

Question:

1. Calculate the maximum height to which water can rise in fabric fibers due to capillarity! and explain why fabrics with finer fibers are more effective for drying the body in this tradition! What will happen to the water absorption process if the contact angle is greater than 90∘? Explain the concept!
2. Compare the absorption capabilities of cotton and synthetic fabrics based on the concepts of adhesive and cohesive forces! and analyze how environmental conditions (e.g., temperature and humidity) can affect the effectiveness of the drying process in this tradition!

Question 6. Physics Concepts of Heat Transfer

During the betangas ritual, the bride and groom sit on a pandan mat that covers the area to trap the hot steam around their bodies. The pandan mat acts as a heat insulator, keeping the temperature inside the betangas chamber high and stable.

It is known that:

- Vapor temperature inside the steam chamber = 600K
- Outdoor ambient temperature = 30°C
- Thickness of the pandan mat = 0.02 m
- Surface area of the mat = 1.5 m^2
- Thermal conductivity coefficient of the pandan mat = 0.05 W/mK

Questions:

1. Calculate the rate of heat transfer (conduction) through the pandan mat!
2. Explain why a pandan mat is more effective than metal in the betangas process!
3. What would happen to the temperature inside the betangas chamber if the mat were replaced with a conductive material? Explain conceptually!
4. How does the thickness of the mat affect its heat insulation capability?
5. Analyze the relationship between this concept of insulation and energy efficiency in the betangas process!

Question 7. Physics Concept: Changes of State of Matter.

In the steam bath process, water mixed with herbs is heated to produce hot steam, which is used for the bride's body treatment. This process involves a change of state from liquid to gas.

Given: • Mass of water = 2 kg • Specific heat of water = 4200 J/kg°C • Initial temperature of water = 30°C • Boiling point of water = 100°C • Latent heat of vaporization of water = 2.26×10^6 J/kg

Questions:

1. Calculate the heat required to raise the temperature of the water from 30°C to 100°C!
2. Calculate the heat required to convert all the water into steam at 100°C!
3. Determine the total heat required for this process!
4. Explain microscopically what happens to water particles during the heating process until they become steam!
5. Why is hot steam more effective in steam-powered processes than ordinary hot water? Explain using physical concepts!
6. Analyze how the amount of heat supplied affects the speed of the steam formation process!

Question 8. Physics Concept: Insulators and Conductors

During the betangas ceremony, the bride and groom sit on a pandan mat, which serves to prevent the heat from the steam from escaping quickly into the environment. The pandan mat is known as an insulating material capable of inhibiting heat transfer.

Given:

• Temperature inside the betangas room = 650K
• Outside ambient temperature = 300°C
• Mat area = 2 m^2
• Mat thickness = 0.02 m
• Thermal conductivity of the pandan mat = 0.04 W/mK

Questions:

1. Calculate the rate of heat transfer (conduction) through the pandan mat!
2. Explain the main difference between insulators and conductors in the context of heat transfer!
3. Why is a pandan mat more effective than metal in the betangas process? Explain based on its physical properties!
4. If the thickness of the mat is doubled, how will this affect the rate of heat transfer? Explain mathematically and conceptually!
5. Analyze what will happen to the temperature in the betangas room if the pandan mat is replaced with a conductor such as aluminum!
6. Explain the relationship between the use of insulators in this tradition and the concept of energy efficiency!

Table 5 shows that, in general, the quality of the test items developed falls into the good to very good category, with the majority of items rated as highly valid by the experts. This indicates that the designed assessment meets the criteria for content appropriateness, cultural relevance, and the ability to foster higher order thinking skills (HOTS). Question 1, which addresses the concept of heat transfer through convection and conduction in the context of a steam engine, was rated as highly appropriate and contextual. This question effectively fosters students' analytical skills, although it is recommended to include visual illustrations to make the described process more concrete and easier to understand. Furthermore, Question 2 on insulators and conductors was also categorized as highly valid due to its relevance to everyday life; however, the terminology still needs clarification to avoid ambiguity among students. For Question 3, which addresses particle equilibrium, the validation results indicate a valid category. This question was assessed as requiring analytical understanding, but it would be more effective if supplemented with an image or sketch to aid in visualizing the concepts of force and torque. Meanwhile, Question 4 regarding work and energy received a "highly valid" rating due to its applied and contextual nature, although improvements are needed regarding the clarity of units and the direction of force.

Next, Question 5, which examines the concept of capillarity, was validated as "valid," with the note that the scientific notation needs improvement to avoid confusing students. In contrast, Question 6 again demonstrated very good quality in its ability to assess students' quantitative analysis skills, although it is recommended to add instructions on how to use the formula to help students solve the problem. Question 7 on the change of state of matter was deemed very comprehensive and received the "highly valid" category. However, the number of sub-questions within a single item was considered excessive, so it is recommended to split it into two separate questions for greater effectiveness. Finally, Question 8, which again addresses insulators and conductors, received the "valid" category, with recommendations to avoid repetitive contexts and increase the variety of problem scenarios. Overall, these validation results indicate that the assessment instrument possesses high quality, both in terms of content and contextual relevance grounded in local culture. The improvement suggestions provided by the experts are primarily technical and constructive; therefore, if implemented, they will further enhance the clarity, comprehensibility, and effectiveness of the questions in optimally measuring student competencies.

Previous research studies have shown that integrating a STEM approach with local culture (ethnoscience) has a significant positive impact on student learning outcomes, particularly in terms of cognitive development, thinking skills, and science literacy(Arciosa & Llanillo, 2025; Nugraha et al., 2023). Various studies report that Ethno-STEM-based learning can enhance conceptual understanding in a more meaningful way because the material is directly linked to students' real-world experiences and cultural environments(Bardoe et al., 2023; Prihatiningtyas et al., 2025; Rodiah et al., 2025). Additionally, this approach has proven effective in enhancing higher-order thinking skills (HOTS), such as critical and creative thinking(Maryna et al., 2025; Trudgett et al., 2025; Zakiyah, 2022), problem-solving and scientific communication skills. From an affective perspective, the integration of local culture into learning helps strengthen scientific attitudes, learning motivation, as well as awareness and appreciation of cultural values(Govender et al., 2025; Snively & Corsiglia, 1998; Villaluz & Malonjao, 2018; Widiyatmoko et al., 2024).

On the other hand, a review of the literature also indicates that a STEM approach grounded in local wisdom can enhance students' active engagement and make learning more contextual and relevant to daily life(Aguayo et al., 2023; Bin et al., 2025; Santos et al., 2025). This leads to increased participation, interest in learning, and a more meaningful learning experience. Nevertheless, several challenges remain, such as limitations in teachers' competencies regarding the integration of culture into STEM learning(Gusman & Yulina, 2023; Milara et al., 2020; Parviz, 2024), a lack of contextual teaching materials, and limited institutional support. Overall, these findings confirm that the integration of STEM and local culture is a promising approach to improving the quality of learning, not only from an academic perspective but also in fostering students' character and cultural identity(Mansour et al., 2025; Prasetyo & Noor, 2022; Wallwey & Kajfez, 2023)This study makes significant theoretical and methodological contributions. Theoretically, this study enriches the field of ethnoscience-based physics education by demonstrating that local traditions such as mandi kasai contain physics concepts that can be systematically integrated into the STEM framework. This broadens the perspective that culture is not merely an object of social study but also a source of contextual and relevant scientific learning. Methodologically, this study offers a model for analyzing and mapping culture-based physics concepts into validated STEM components, thereby serving as a reference for future research on the integration of science and local culture(Arce et al., 2022; Arciosa & Llanillo, 2025).

In practical terms, this study contributes to the development of a context-based physics learning model that utilizes the Mandi Kasai tradition as a learning resource, thereby helping teachers connect abstract concepts with students' real-world experiences. Additionally, this study develops authentic, context-based learning assessments integrated with STEM(Fajriyani, 2023; Mbah & Hill, 2025), including project-based, performance-based, portfolio, and case study assessments. This assessment measures not only cognitive aspects but also students' process skills and scientific attitudes, thereby supporting more meaningful, holistic learning that aligns with the demands of a curriculum oriented toward the development of 21st-century competencies(Maryna et al., 2025; Shidiq et al., 2023; Suastra & Pujani, 2021).

4. CONCLUSION

The results of this study indicate that a). The kasai bathing tradition incorporates various contextual physics concepts, including heat and heat transfer (conduction, convection, and radiation), phase changes (evaporation), fluids (water flow), and thermal equilibrium, which were identified through observation, interviews, and documentation and validated through triangulation of sources. b). A STEM framework encompassing Science (concepts of heat and temperature), Technology (use of traditional tools and techniques), Engineering (design of heating systems and flow regulation), and Mathematics (measurement of temperature, volume, and time), with expert validation results indicating a suitable category. c). A reconstruction of contextual physics learning assessments that integrate the Kasai bathing tradition through authentic assessments, which have been validated and deemed valid and practical. Thus, the integration of ethnoscience into learning serves as an effort to create physics instruction that is more meaningful, contextual, and relevant to local culture, while simultaneously strengthening the preservation of local wisdom within the educational sphere. Recommendations for future research should focus on testing the model's effectiveness on a broader scale, with the expectation that it will have an impact on the understanding of physics concepts and science literacy. Further research is needed to examine the long-term impact on physics concepts within the STEM field, while analyzing teacher readiness and developing TPACK-based training will be key to sustainability in the field, as well as to developing an integrated theoretical model that connects indigenous knowledge, STEM, and AI-assisted learning as a new contribution to contextual science education.

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