

Reading Physics Through Tanean Lanjhang: Traditional Settlement Patterns as Cultural Contexts for Science Education

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This phenomenon has a direct impact on the low level of participation among young people in cultural activities and the preservation of cultural heritage. A study conducted by Röll and Meyer (2020) shows that young people often view cultural heritage primarily as a part of the past or as monumental objects, making cultural experiences feel disconnected from their daily lives. The lack of relevant experiential context and the dominance of modern global culture contribute to a perception of cultural heritage that feels disconnected from the lived reality of the younger generation. This perception makes the involvement of the younger generation in local cultural practices increasingly rare, especially within modern societies that prioritize efficiency, mobility, and pragmatic values. Digital technology has a dual impact on cultural identity: on one hand, it expands the space for expression and access to local culture, global influences, and digital media; on the other hand, it poses serious challenges to the preservation of traditional cultural values (Bani Issa 2025). The decline in young people's engagement with culture is also closely linked to a lack of cultural experiences from an early age (Keuchel 2013; Kim et al. 2024). Children's participation in cultural activities has a positive correlation with prosocial behavior and social engagement in adulthood (Hosokawa, Katsura, and Taira 2022; Yamaoka et al. 2021). Thus, when younger generations no longer gain cultural experiences from an early age, their future engagement with cultural values and practices is also likely to diminish (Garrod et al. 2020). This situation highlights the need for systematic efforts to re-examine the role of culture in shaping the adaptive knowledge and values embedded in cultural practices. Therefore, studies on culture across various academic disciplines are necessary as a foundation for maintaining the relevance and sustainability of cultural heritage, so that culture is not merely viewed as a symbolic legacy but also as a meaningful source of knowledge.

The Integration of Culture and Education

Education and culture play a vital role in instilling and developing the nation's noble values, which contribute to character building and the strengthening of students' self-confidence. Culture, as an activity inherent to a specific social community, significantly influences students' mindset, character, and learning styles (Sakti, Endraswara, and Rohman 2024). The application of culture as a theoretical framework to enhance student engagement and the understanding of scientific concepts within the educational context in South Africa, by positioning cultural values as an integral part of the science teaching structure (Mudaly 2020). This demonstrates how an approach that values local cultural knowledge can expand scientific understanding beyond the traditional Western paradigm (Ajayi 2025). Integrating local wisdom into education can help students and educators understand how to utilize local knowledge to address the environmental and social challenges that continue to emerge simultaneously. Education is believed to play a crucial role in preserving and passing down local wisdom, while also educating communities to live in harmony with traditional values (Lestari, Paidi, and Suyanto 2024a). Local wisdom is utilized as a model for interfaith communication in fostering religious harmony (Gede Agung et al. 2024). Furthermore, local wisdom is also linked to environmental conservation to support the realization of sustainable tourism (Dian, I Gusti Putu, and Slamet 2018).

Research on the integration of local wisdom into education has garnered significant attention in the academic world, with a global trend of increasing publications. A bibliometric analysis indicates that the topic of local wisdom in education has experienced consistent growth from 2020 to 2024, encompassing various aspects of learning and contextual pedagogical approaches. The results of this study also indicate that the integration of local cultural values into education is not only relevant for cultural preservation but also contributes to enhancing the broader relevance of education (Arjaya et al. 2024). A study by Zidny and I. Eilks (2020)

found that integrating local knowledge into education can prevent the marginalization of local wisdom and promote aspects of the SDGs (Zidny and Eilks 2020). The integration of culture into the learning process has the potential to create meaningful learning experiences. Science learning that integrates students' cultural backgrounds has the potential to enhance the relevance and meaning of scientific concepts in their lives, thereby expanding the meaning, imagination, and creativity in their understanding of formal science. Culturally-based learning not only serves as a means of cultural transmission and representation but also utilizes culture as a context to help students expand meaning, develop imagination, and enhance creativity in achieving a deep conceptual understanding of learning materials, particularly in formal science understanding (Smith, Avraamidou, and Adams 2022).

Most researchers have found that local wisdom has been incorporated into various fields of education. This integration includes the teaching of Indonesian (Manuhutu et al. 2025; Fauziah, Saddhono, and Suryanto 2023), Arabic (Al Farisi et al. 2024), English (Munthe et al. 2025), civic education (Afandi et al. 2026), entrepreneurship education (Rizka et al. 2025), drama education (Ahmad Ripai 2025), character education (Hidayati et al. 2020), and even digital learning (Subandi et al. 2026). Additionally, the integration of local wisdom has also expanded within the sciences, such as mathematics education, biology education (Budiarti, Harlis, and Natalia 2020; Hadi et al. 2020; Herak et al. 2025), chemistry education (Anugrah 2021; Kiwfo et al. 2021), and physics education (Mashoko 2022; Nadzirin et al. 2024; Pejaner and Mistades 2020; Susanto et al. 2021). This indicates that local wisdom holds vast potential as a source of knowledge, particularly knowledge that is contextual and relevant to students' lives. The integration of culture into learning not only enriches instructional materials but also provides experiences that are more closely aligned with students' social and environmental realities. Thus, local wisdom functions not only as a cultural identity but can also serve as a relevant source of scientific reflection for understanding various natural phenomena. Therefore, the exploration of local wisdom in an educational context needs to be directed more specifically toward strengthening and developing concepts, including in physics education.

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Culturally Responsive Physics Education

The study of culture in science education particularly physics has become increasingly important in recent years. Overall, the study of culture in science education is a rapidly evolving field that encompasses a wide range of disciplines and perspectives. A systematic review of trends in science education research indicates that the integration of culture into learning has grown steadily from the 1970s to the present. Culturally-based approaches, including the

utilization of local knowledge and social contexts, are increasingly being used to help students understand abstract scientific concepts (Zheltukhina et al. 2023). Culturally responsive physics education seeks to connect formal physics concepts with students' cultural backgrounds and life experiences. This synergistic integration stimulates critical thinking by encouraging students to analyze the interactions between cultural practices and physical phenomena. The direct correlation between an appreciation for cultural heritage and a deeper understanding of scientific principles underscores the effectiveness of ethnophysics in fostering a more holistic and engaging learning experience (Fakhruddin et al. 2026). When physics instruction ignores cultural context, students tend to view physics as abstract knowledge disconnected from their reality. Field experience indicates a lack of use of cultural context or local wisdom in instruction, which causes students to struggle to connect theory and reality (Carter et al. 2024).

Local and indigenous knowledge (LIK) has been incorporated into science education in countries such as Canada, South Africa, the United States, and Australia, through diverse integration strategies relevant to various phenomena in physics and other natural sciences (Latip, Hernani, and Kadarohman 2024). In addition, empirical research in Chókwé (a remote village in Mozambique) demonstrates how traditional indigenous knowledge relates to physical concepts that can then be adapted to the context of formal education (Baquete, Grayson, and Mutimucuo 2016).

To date, physics studies grounded in local wisdom have generally focused on cultural practices of an artifactual nature and functional activities, such as traditional cuisine (Hartini et al. 2018; Jufrida et al. 2025; Rusmaya et al. 2025) traditional games (Deta et al. 2026; Fakhruddin et al. 2026; Jufrida et al. 2025), traditional houses (Jufrida et al. 2025), daily activities (Pejaner and Mistades 2020) and cultural artifacts (Anantanukulwong et al., 2023; Budiarti et al., 2020; Ha, 2024; Mashoko, 2022) as objects of study. A study in Zimbabwe demonstrates that cultural artifacts can serve as scientific resources to connect physics concepts with students' lived experiences, thereby making science a culturally grounded approach to understanding the world, rather than merely an accumulation of facts (Mashoko 2022). Although the integration of culture within the context of physics has been extensively studied, research specifically identifying local wisdom in the layout or patterns of traditional settlements from a physics perspective has yet to be found. Taneyan Lanjhang, as one form of local wisdom among the Madurese people of Indonesia, has not been systematically explored to uncover the potential physics concepts contained within it. In fact, identifying physics concepts within local wisdom is an important first step toward developing contextual and culturally responsive physics education.

Therefore, this study focuses on identifying physics concepts within local wisdom as reflected in the layout of traditional Madurese settlements through the *Taneyan Lanjhang* system. This focus is expected to broaden the scope of culture-based physics studies from artifactual practices to settlement systems as a unified cultural space, while also making a new contribution to the development of contextual physics education rooted in local culture.

METHOD

This study employs a qualitative descriptive approach using ethnographic methods (Anantanukulwong et al. 2023). The qualitative approach aims to explore phenomena in depth, thereby yielding a comprehensive understanding of real-world realities and contexts (Sabon Dominikus and Madu 2025). This is an appropriate method for producing in-depth descriptions of culture and behavior (Mahendra et al. 2024) focusing on the description and understanding of how a community functions as a group sharing a culture or as individual representatives of that group. Ethnographic research was used in this study to identify physics concepts within the local wisdom of the settlement patterns of the Madura Taneyan Lanjhang community, which also holds potential for integration into physics education.

DATA COLLECTION

Data collection in this study was conducted through three complementary stages using a series of techniques rooted in ethnographic methods to gain a deep and comprehensive understanding of the local wisdom underlying the settlement patterns of *Tanean Lanjhang* and their connection to concepts in physics. The techniques employed reflect well-established qualitative data collection practices known to be effective in cultural and social phenomenon research (Candra Susanto et al. 2024). Ethnography is a type of qualitative research that collects observations, interviews, and documentary data to produce a detailed and comprehensive description of social phenomena occurring within the real-life context of the research subjects (Reeves et al. 2013).

Research data was collected through field observations in the *Tanean Lanjhang* settlement to identify physical phenomena in the spatial layout and community interactions with the environment, supported by visual documentation in the form of photos and videos. The observation was conducted on August 18, 2025, lasting 3 hours, and was supported by visual documentation in the form of photos and videos to reinforce the empirical data. Semi-structured interviews were conducted with the community leader in the *Tanean Lanjhang* settlement as a key informant to explore community practices, the cultural significance of *Tanean Lanjhang*, and its connection to physical concepts. The interview took place on August 19, 2025, and lasted 90 minutes.

DATA ANALYSIS

Data analysis in this study was conducted using a descriptive qualitative approach, employing narrative analysis and inductive coding, as applied by Anantanukulwong et al. 2023 in uncovering funds of knowledge rooted in local culture. This analysis aims to interpret cultural phenomena within the *Tanean Lanjhang* community.

Data analysis begins with reduction-that is, filtering, simplifying, and focusing (Susilawaty et al. 2025) on relevant information from interviews, observations, and documentation to understand the lifestyle, settlement structure, and practices of the *Tanean Lanjhang* community. Next, inductive coding was conducted, in which cultural phenomena were coded and grouped into physical concepts. The data were presented in categories, themes, tables, and visualizations of relationships between concepts to systematically trace patterns and interconnections. To ensure the validity of the data from observations and interviews and to strengthen the analysis, a Focus Group Discussion (FGD) was conducted with experts. This activity involved five experts: two materials physicists, one geophysicist, one learning innovation expert, and one education expert. The FGD was held as a single session lasting 3.5 hours. The final stage involved drawing conclusions that linked physical phenomena to the local wisdom of *Tanean Lanjhang*.

ETHICAL CONSIDERATIONS

This study was conducted following ethical approval granted by the Institute for Research and Community Service, Universitas Islam Madura. Prior to data collection, all participants were informed about the purpose of the study, the procedures involved, and the intended use of the data for academic publication. Written informed consent was obtained from all participants before their involvement in the study. In addition, participants explicitly granted permission for the documentation and publication of visual materials related to their residential environment, including images of their houses, for research and scholarly dissemination purposes. Participation was voluntary, and the researchers ensured that the use of visual and narrative data remained consistent with the consent provided by the participants.

RESULTS

Observations conducted in the traditional settlement areas of the Madurese community in Indonesia indicate that the spatial layout of traditional Madurese settlements exhibits a strong sense of order and scientific functionality. This spatial system is not merely a cultural symbol but embodies scientific principles that can be explained through physics. Interviews with the head of the *Tanean Lanjhang* settlement community revealed that the community already understands thermal comfort within their homes, even though they are unaware that these practices actually represent physical concepts.

Table 1. Mapping of Physics Concepts to Elements of Local Wisdom

No	Elements of Tanéan Lanjhang Local Wisdom	Identified Physical Concepts
1	Linear settlement pattern (layout)	Bernoulli's principle, airflow
2	Building orientation	Solar radiation
3	Ventilation and windows	Cross ventilation, fluid dynamics
4	Traditional building materials	Thermal, heat transfer by conduction,
5	Roofs	Heat transfer by radiation, conduction, and convection

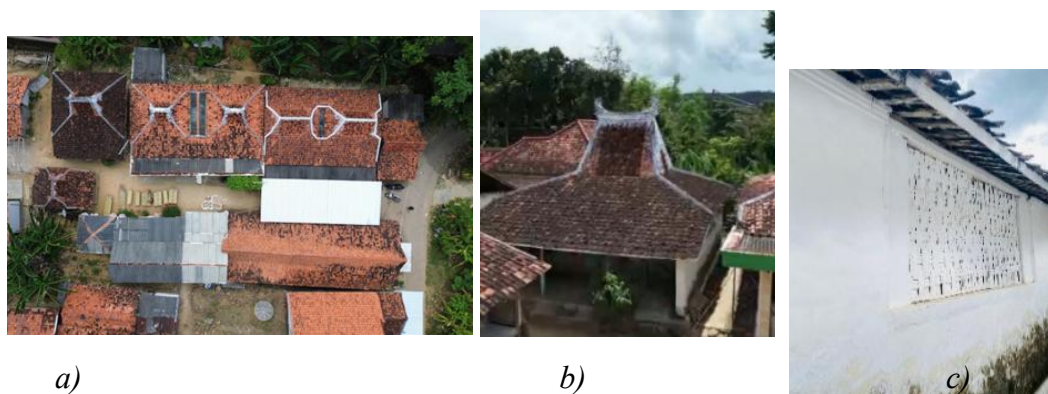


Figure 1. a) Settlement pattern (layout) & building orientation b) Ward roof c) Wall materials

The settlement pattern of *Tanean Lanjhang* features a structured spatial layout and is not built haphazardly. "This settlement system consists of a long courtyard with the main components being a south-facing house, an east-facing kobhung, a kitchen, and a livestock pen located side by side." The layout and length of the courtyard influence family activity patterns

as well as social interactions among family members. The spatial arrangement of *Tanean Lanjhang* tends to be preserved from generation to generation without the addition of structures that alter the original layout. This demonstrates a sense of order and consistency in settlement construction practices. The courtyard serves as a multifunctional space, including for drying agricultural produce, family activities, and as a playground for children, although its functions have begun to diminish in modern practice. Beyond physical aspects, the Tanéan Lanjheng settlement embodies strong social and cultural values. Women's privacy is strictly guarded, reflected in the presence of a single main entrance to the house and the custom of receiving guests outside the home. This practice reflects the values of prudence and the preservation of family honor.

The value of mutual cooperation is still practiced in the community of Tanéan Lanjheng and has been passed down through generations within families as part of moral values and the attitude of *andep asor* (humility and politeness). The community also tends to preserve existing structures because Tanéan Lanjheng is considered to hold sacred significance. Alterations to existing buildings are not permitted, and new construction must be carried out on other land.

Physical concepts are embedded in the local wisdom of the *Tanean Lanjhang* settlement. The layout of the *Tanean Lanjhang* settlement demonstrates Bernoulli's principle in airflow. The conditions within the *Tanean Lanjhang* compound cause airflow acceleration, resulting in lower pressure inside the compound compared to outside the *Tanean Lanjhang* settlement. Additionally, there is a height difference in the ventilation system. This explains why houses with ventilation experience better air circulation, as shown in Figure 2.

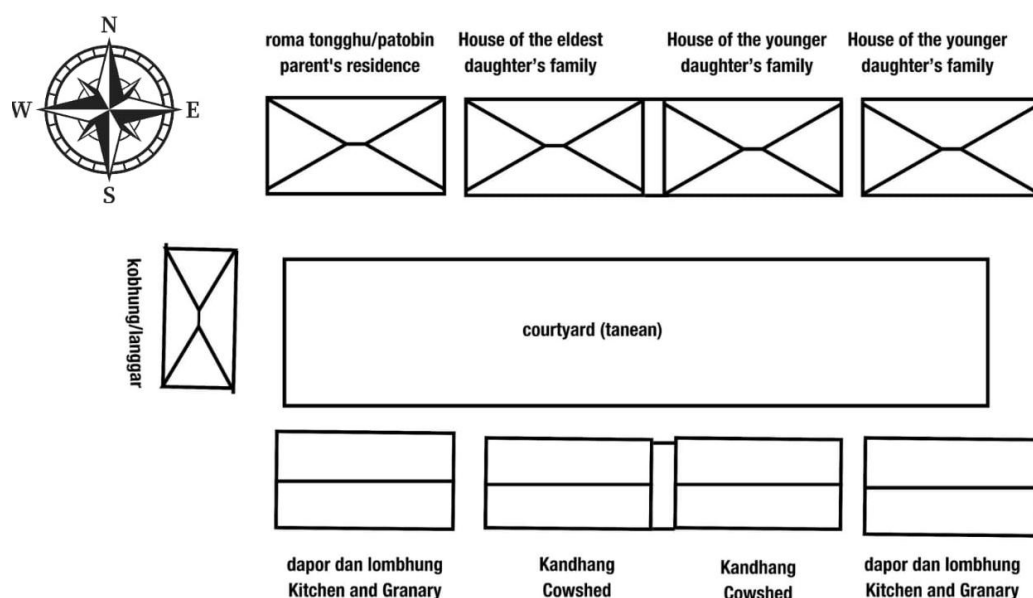


Figure 2. Sketch of the *Tanean Lanjhang* Settlement Pattern

The traditional Madurese settlement pattern known as *tanean lanjhang* features buildings arranged in rows facing each other, forming an open courtyard in the center called a *tanean*. In the *tanean lanjhang* layout, structural elements such as the main house, kitchen, and *langgar* are arranged linearly in a face-to-face configuration. Houses face south, while the kitchens and animal pens, situated across from them, face north, and the *kobhung/langghar* faces east. This configuration creates an open courtyard in the center called the *tanean*, which allows for the formation of a natural pathway for airflow. Generally, during the dry season, winds in the Madura region blow from east to west. Air from the east in the Madura region

generally moves freely in open spaces. Outside residential areas, airflow spreads in all directions because there are few obstacles in the vicinity. However, when this wind enters the taneyan lanjhang area, its flow pattern begins to change significantly, as shown in Figure 3.

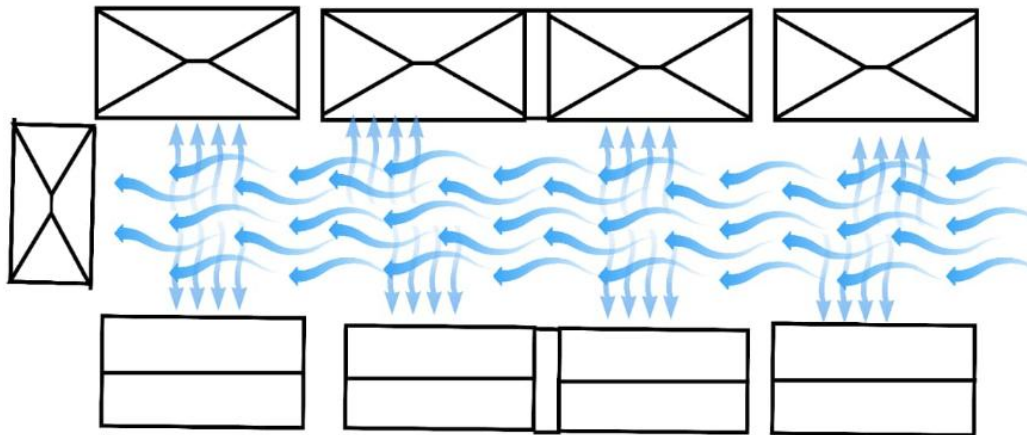


Figure 3. Airflow in the *Taneyan Lanjhang* settlement

The layout of the *Taneyan Lanjhang* settlement causes the air in the central courtyard to appear as if it is enclosed by buildings on both sides, narrowing the flow path and increasing air velocity. As a result, the air flows rapidly through the house via the vents and window openings in the front wall, as shown in Equation 1.

$$P_a + \frac{1}{2}\rho v_a^2 + \rho v h = P_b + \frac{1}{2}\rho v_b^2 + \rho v h \dots \dots \dots (1)$$

In addition, the difference in elevation between the yard and the house's ventilation opening reinforces Bernoulli's principle. Since the ventilation opening is slightly higher than the yard's surface, the high-speed air below rises toward the opening. Once the air enters the house, its flow velocity decreases because the interior space is enclosed and does not allow the air to move freely. According to Bernoulli's principle, this decrease in velocity causes an increase in air pressure inside the house. The pressure difference between the air inside and outside the house drives the formation of natural air circulation, which results in a temperature difference. This phenomenon demonstrates that the people of Madura have applied Bernoulli's principle of physics in their traditional architecture, which not only serves social and cultural functions but also maintains the house's coolness through an efficient natural air circulation mechanism.

One source stated, "It's cool inside the house, even though it's hot outside." This statement is supported by physical concepts, including heat transfer via radiation, conduction, and convection.

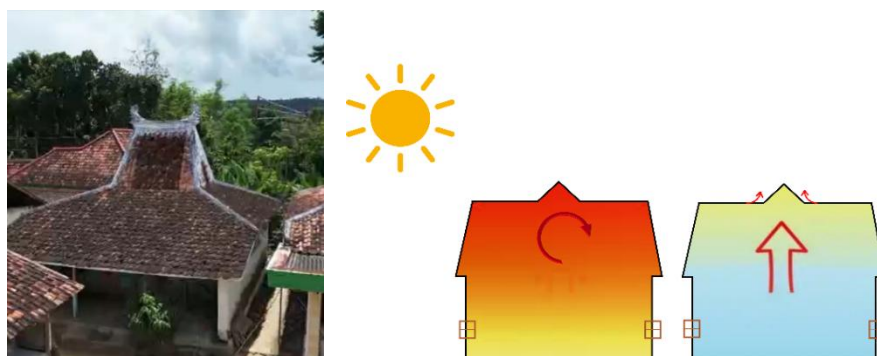


Figure 4. Roof of a traditional Javanese house & sketch of heat transfer by convection

The phenomenon of heat transfer in residential buildings can be explained through basic principles of physics, specifically radiation, convection, and conduction. In terms of radiation and conduction, the clay roof (tiles) absorbs heat; some of it is radiated outward, while some is conducted inward. The roof of a house in the taneyan lanjhang style resembles the joglo type a traditional Javanese architectural style featuring a tiered structure known as tumpang sari, supported by four main pillars called soko guru. The roof resembles a mountain with a steep slope and a limasan (gable) in traditional Javanese architecture. The roof of a bangsal house (a traditional Madurese dwelling) is joglo-shaped with the sides cut off, and some have a simple limasan shape with a cavity. This unique and fairly high roof allows cool air to circulate within the room.

Theoretically, hot air has a lower density than cold air. As a result, hot air inside a room tends to rise to the top through natural convection, because the density (ρ) of the hot air is lower than that of the cooler outside air. This movement allows the hot air to be pushed out through openings such as vents, roof gaps, or windows located at higher positions, thereby helping to maintain air circulation and lower the indoor temperature.

In addition to convection, heat transfer also occurs via conduction through the roof and walls of the building. The walls of the ward house, constructed from natural materials such as fired bricks, earth, and white lime, possess specific thermal characteristics. Red bricks are known to have a relatively high ability to absorb and store heat, approximately 70–75%. Meanwhile, the 10–15% white lime content acts as a thermal insulator that can slow the rate of heat transfer into the building. The combination of these material properties prevents heat from the outside from being fully transferred into the room, so the interior temperature of the house tends to be more stable and relatively cooler.

DISCUSSION

This study investigates how the knowledge embedded in the traditional settlement pattern of the Madurese people, known as Tanéan Lanjhang, can be used to teach fundamental physics concepts. The results of this study indicate that Tanéan Lanjhang not only represents a traditional settlement system but also embodies local wisdom containing physical principles applied empirically in the daily lives of the Madurese community. It holds potential for integration into the formal school physics curriculum, enabling students to learn physics in a way that is easily understood and meaningful. These findings can contribute to the development of innovative physics lessons that integrate local knowledge. Scientific knowledge does not always exist in formal forms but can develop through cultural experiences and practices passed down through generations (Akhmar et al. 2023; Wirama, Suja, and Tika 2023).

Integrating local wisdom into education can support sustainable education programs by providing students with a strong foundation for developing an understanding of sustainability, preserving their cultural heritage, and applying sustainable practices in their daily lives (Lestari et al., 2024). Culturally responsive teaching encompasses “a comprehensive pedagogy based on the idea that culture directly influences teaching and learning and plays a vital role in how we communicate and receive information.” By integrating physics with Funds of Knowledge (FOK) which are the collections of knowledge, experiences, and cultural practices that students acquire through active engagement in multiethnic social communities-into physics learning, students contribute to enhanced conceptual understanding by bridging abstract physics concepts to the context of everyday life experiences and practices. (Isa, Bunyamin, and Phang 2022). Integrating culture into the concept of physics can address misunderstandings and quickly resolve them (Ali, 2017). When physics teachers can design culturally-based lesson plans, they will be better prepared to identify cultural elements relevant to physics (Soko, Setiawan, and Widodo 2019). Students struggled to understand the definitions in the textbook. Therefore, teachers created their own examples and explanations of physics concepts based on contexts

provided to the students. For example, teachers use students' concepts of riding and driving, making pots, and vehicles based on community contexts to teach motion (specifically, speed, velocity, and acceleration), energy, and the second law of motion. Incorporating students' daily activities is the only way for them to integrate culture into physics instruction (Pejaner and Mistades 2020). Local and indigenous knowledge (LIK) has been incorporated into science education in countries such as Canada, South Africa, the United States, and Australia, using a variety of integration strategies relevant to various phenomena in physics and other natural sciences (Latip et al. 2024). In addition, empirical research in the Chókwé community (Mozambique) demonstrates how traditional indigenous knowledge relates to physical concepts such as mechanics, static electricity, and thermodynamics, which can then be adapted to the context of formal education (Baquete et al. 2016).

The hearth or central space in traditional settlements is typically a "natural" open area that allows for free air circulation and serves as an integral part of community life. During the day, the sun provides abundant light, while the trees under which the fire is built offer shade to those gathered. At night, the moon usually provides good illumination. However, if there is no moon, the fire can serve as a light source. The fire used for cooking also serves as a very useful source of light. This phenomenon reflects the social context in which teaching and learning activities take place. Such spaces are characterized by good lighting, whether generated by electricity or provided by sunlight. Ventilation can also be ensured through air conditioning or fresh air from the surrounding environment where the classroom is located. Classrooms can be surrounded by nature, plants, and greenery (e.g., trees, shrubs, and grass) and illuminated by the sun. Furthermore, cooking activities, starting from the pre-cooking stage, involve the following physical phenomena: Fire-making Friction occurs when two stones or sticks are struck together to create fire. Energy transfer (conduction) The equipment used is a good heat conductor; Heat production-Fire generates heat for cooking; Balance of forces replicated in three rock structures; States of matter-solid, liquid, and gas (Ajayi 2025).

The settlement pattern of Tanéan Lanjheng forms a spatial configuration that indirectly controls the dynamics of airflow within the residential environment. The elongated courtyard located at the center of the settlement is surrounded by buildings on both sides and a kobhung on the western side, thereby creating a relatively narrow flow channel. When air from the east enters this area, the narrowing of the airflow space causes an increase in air velocity before it eventually disperses and flows into the interior of the house through vents and window openings in the front wall. This phenomenon demonstrates the natural application of fluid dynamics principles in the spatial layout of Tanéan Lanjheng. This finding is supported by research Shen *et al.*, (2024) regarding the traditional layout of villages in Fujian, which shows that a complex network of roads and the strategic placement of buildings can act as natural windbreaks. Thus, the spatial design of Tanéan Lanjheng allows air to move more quickly through the courtyard area and be drawn into the house.

In addition, the difference in elevation between the yard and the house's vents reinforces Bernoulli's principle. Since the vents are slightly higher than the yard's surface, the high-speed air below rises toward the vents. The pressure difference between the air inside and outside the house drives the formation of natural air circulation. This pressure difference results in a temperature difference. In this house, there are vents and windows at the rear that help maintain optimal air circulation. Air movement occurs due to differences in temperature and air pressure between two different locations, with the key factor in cross ventilation being the presence of two openings on opposite walls (Sudirman et al. 2024). Jiang dkk (2023) also agree on the benefits of cross ventilation, namely that this method is an effective way to circulate air and remove heat through differences in air pressure, which are influenced by openings and designs that allow air to move freely. One of the requirements for creating good ventilation is ensuring cross airflow. By placing openings on both sides of the room, this allows air to enter and exit

efficiently. This allows airflow even when the wind is not very strong, thereby helping to maintain optimal air circulation within the room. Larger, strategically placed window openings optimize airflow, improve ventilation efficiency, and enhance indoor air quality (Demir and Aktepe 2025).

A study of wind pressure coefficients shows that a building's configuration and orientation affect the distribution of pressure on the building's surface and the surrounding space (Xie et al. 2023). As air moves through the gaps between buildings and open spaces, the airflow velocity increases, causing the pressure to drop a phenomenon consistent with Bernoulli's principle. This pressure difference drives the airflow, thereby enhancing natural air circulation in the *Tanean Lanjhang* settlement. The central courtyard and the orientation of the buildings amplify the Bernoulli effect, promoting natural cooling and ventilation.

In addition, a study Kosutova *et al* (2019) examined air pressure and flow velocity in Bernoulli-based passive ventilation systems. Different opening positions, such as at the top, middle, or bottom of a building, influence airflow patterns and distribution within a room. For example, openings at the top tend to facilitate efficient airflow in and out due to the influence of wind pressure and gravity, thereby enhancing air circulation and exchange. In the case of Taneyan Lanjhang, houses with higher roofs and small vertical openings allow hot air to escape more quickly than houses with low roofs. Taneyan houses feature joglo-style roofs and simple saddle or gable roofs with voids. The temperature inside the house tends to be lower than in the surrounding outdoor areas, especially during the day. This bangsal house has a unique and fairly high roof, which helps keep the air inside cool. In line with this, hot air has a lower density than cold air (Yang and Seidel 2023). When hot air is inside a room, it tends to rise, while cooler air remains in the room. Hot air inside a house tends to rise (natural convection) because the density (ρ) of hot air is lower than that of the cooler outside air (Mauri 2023). When there are openings (ventilation, roof gaps, high windows), the hot air is pushed out.

Traditional houses such as the Joglo and Limasan feature a high roof-to-wall volume ratio with tall vertical spaces. The expansive roof space allows hot air to rise and escape through the gaps in the roof trusses, keeping the lower part of the house cool. This design simultaneously enhances the building's thermal comfort and energy efficiency. Such a structure is found in the Bangsal house in Taneyan Lanjhang. Effective passive cooling strategies for achieving thermal comfort involve controlling solar radiation and optimizing natural ventilation. Roof and shading elements play a crucial role in reducing solar heat, while openings and interior layout support air circulation within the building (Idham 2018). The high roof volume allows hot air to rise and escape, while the white-washed brick walls act as a thermal insulator that slows the transfer of heat from the outside into the house. Whitewash reflects solar radiation, helping to keep the indoor temperature stable. However, Research (Tominaga, Zhang, and Miyakoshi 2024) roof pitch has a significant effect on a building's natural ventilation. In wind tunnel studies, roofs with steeper slopes create a greater wind pressure difference, thereby enhancing airflow from inside to outside the building through natural openings. This is consistent with the principles of aerodynamics and Bernoulli's principle, where changes in airflow velocity around the roof surface generate a pressure gradient that drives natural air movement. Furthermore, research (van Hooff et al. 2019) shows that an aerodynamic roof geometry can create low-pressure zones due to airflow, which in turn promotes natural ventilation through the pressure differences that occur on the roof surface.

The wall structure of traditional *Tanean Lanjhang* houses is made of a mixture of fired bricks, soil, and white lime. According to interviews with local residents, the walls are made of a mixture of fired bricks, soil, and white lime that has been left to settle for about 40 days. This combination results in walls with varying heat absorption coefficients—approximately 70–75% in the brick sections and only 10–15% in the white lime layer. Consequently, the interior of the

house feels cooler compared to the veranda or exterior, in addition to the effects of convection and airflow. A source stated, “It’s cool inside the house, even when it’s hot outside.”

Physically, this phenomenon is related to heat conduction. White lime has low thermal conductivity, thereby slowing the rate of heat transfer from the outside into the house. Research by Posani, Veiga and de Freitas (2023) explains that brick walls coated with porous materials and traditional lime possess good thermal insulation properties because their hygroscopic nature maintains a balance of temperature and humidity. The study also confirms that the use of lime-based thermal render and natural materials can enhance indoor thermal comfort while maintaining water vapor circulation, thereby preventing the accumulation of excess heat and humidity. Thus, the design of the traditional house not only serves architectural and cultural functions but also has strong physical implications for ventilation efficiency, thermal comfort, and the structural stability of the building against wind. From an educational perspective, this phenomenon holds great potential as a physics learning material rooted in local wisdom through the observation of real-world phenomena in their environment.

From an educational perspective in physics, these findings underscore the importance of a locally-based learning approach. Contextual learning rooted in culture helps teachers connect the material being taught to students’ real-world situations and encourages students to make connections between the knowledge they possess and its application in their daily lives (Purwanto, Sunarno, and Aminah 2015). Unlike previous ethnophysics research, which has largely focused on cultural artifacts such as traditional tools, games, or cooking activities, this study positions the spatial layout of settlements as an authentic and holistic source of physics learning. This approach allows students to observe physical phenomena directly in their everyday environments, making abstract concepts such as heat transfer, fluid flow, and energy balance more meaningful. Furthermore, empirical research in Mozambique demonstrates how traditional indigenous knowledge relates to aspects of physics such as mechanics, static electricity, and thermodynamics, which can then be adapted to the context of formal education (Baquete et al. 2016).

This aligns with context-based learning, which emphasizes the connection between scientific concepts and students’ real-world experiences. Recent research findings (Melesse et al. 2025) indicate that context-based learning can enhance conceptual understanding, engagement, and students’ ability to apply knowledge to everyday situations. These findings are also supported by other research confirming that a contextual approach in science education contributes to increased student engagement and critical thinking skills because students are directly engaged with real-world phenomena (Pursitasari et al. 2020). Thus, *Tanean Lanjhang* not only represents the cultural identity of the Madurese people but also reflects a local knowledge system aligned with the principles of physics. The results of this study confirm that integrating local wisdom into physics instruction can serve as an effective, contextual, and sustainable pedagogical strategy, while simultaneously contributing to the preservation of local culture within the formal education system.

CONCLUSION

This study identifies that there are physics concepts within the traditional settlement patterns of the Madurese *Tanean Lanjhang*, namely Bernoulli’s principle regarding air pressure and wind flow, which explains natural ventilation; heat conduction in house walls that maintains temperature stability; and the concept of convection in the bangsal houses, which plays a crucial role in creating air circulation and thermal comfort within the settlement environment. This proves that local cultural values can be explained through a scientific approach and have great potential to be used as a learning resource in physics education based on local wisdom. The analysis results indicate that these physical phenomena have the potential to serve as a contextual framework for physics education that is closely aligned with students’ daily lives.

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