Fishermen's Local Knowledge of Astro-Oceanographic Phenomena for Contextual Physics Education and Disaster Preparedness in Puger: A Qualitative Case Study

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Abstract

Puger coastal area in Jember Regency is vulnerable to both geological disasters (megathrust earthquakes and potential tsunamis) and hydrometeorological hazards, making fishermen's disaster preparedness an important part of risk reduction. This study aims to explore the local knowledge of Puger fishermen in observing environmental phenomena and to map its relevance to physics concepts as a context for physics learning and disaster literacy. This qualitative descriptive study involved ten informants (seven senior fishermen, two younger active fishermen, and one community figure) selected through purposive sampling. Data were collected through semi-structured interviews, field observation, and documentation, analyzed thematically, and validated through technique triangulation and member checking. The results show that Puger fishermen possess local ecological knowledge involving observation of the Moon and stars' positions (including the Talu-talu Star for traditional navigation), wind direction, wave characteristics, seawater color, and tides, which coexists with digital weather applications among younger fishermen. A sudden recession of seawater is believed to signal an impending tsunami, though this must be distinguished from scientifically validated early warning systems. The Petik Laut tradition functions as social capital strengthening community solidarity rather than as a direct disaster mitigation mechanism. Findings were mapped onto concepts of gravity-tides, mechanical waves-tsunamis, fluid dynamics-wind, and astronomy-navigation. This study provides an empirical foundation for developing contextual physics learning resources rooted in coastal community experience.

Keywords: *Local wisdom; fishermen's knowledge; disaster preparedness; coastal communities; Puger coastal area.*

INTRODUCTION

Indonesia is located in the Ring of Fire and at the junction of three of the world's active tectonic plates, making it one of the countries with a high risk of geological disasters. Its location in the tropics also contributes to the high frequency of hydrometeorological disasters such as extreme weather, storm surges, and tidal flooding, with coastal areas being particularly vulnerable to the impacts of both types of disasters (National Disaster Management Agency [BNPB], 2023). Given the limitations of structural mitigation measures, the preparedness of local communities plays a crucial role in efforts to reduce disaster risks and impacts. This preparedness can be strengthened by drawing on local knowledge, community experience, and available disaster information (Unmehopa., 2025). In this study, preparedness is limited to fishermen's ability to recognize environmental signs, take weather and wave conditions into account, and make safety decisions during fishing activities.

KThe Puger Coastal Area in Jember Regency is one of the southern coastal regions of Java that directly faces the Indian Ocean. Puger faces geological threats in the form of megathrust earthquakes and the potential for tsunamis. Jember is listed as one of the regions in East Java that is potentially at risk from a megathrust earthquake in southern Java (Indonesian Agency for Meteorology, Climatology, and Geophysics [BMKG], 2026). This potential is also demonstrated through tsunami propagation modeling based on a megathrust earthquake scenario off the southern coast of Java (Adventari *et al.,* 2021). In addition, coastal communities also face hydrometeorological threats such as weather changes and high waves. These conditions are directly related to the safety of the people of Puger, most of whom

depend on the fishing industry for their livelihoods; therefore, changes in wind, waves, tides, and weather are key factors in determining the safety of fishing activities.

In response to these environmental dynamics, fishermen have developed various forms of local knowledge through their experiences and long-term interactions with the coastal environment. This local knowledge is passed down across generations through community narratives and practices, with community leaders playing a key role in transmitting knowledge rooted in local wisdom (Fakhruddin & Elmada, 2022). For fishing communities, knowledge of weather changes, wind direction, waves, tides, and natural signs serves as the basis for determining the timing and safety of fishing activities (Lawalata *et al.,* 2022). This ability demonstrates that the community's experience in observing the environment plays a role in shaping their capacity to recognize and respond to risky conditions.

Fishermen's local knowledge is not intended to replace scientific information or official early warning systems. In community-based mitigation, local knowledge, experience, and capabilities play a vital role in enhancing communities' capacity to cope with disaster risks (Syarif *et al.,* 2025). Community capacity-building can also be achieved by integrating local knowledge with modern information and early warning systems (Fitri *et al.,* 2023). Therefore, local knowledge must be carefully analyzed by distinguishing between community observations and experiences, the accompanying cultural meanings, and environmental indicators that have scientific explanations. Local wisdom itself is knowledge that has evolved from the customs and experiences of communities as they have adapted to their environment over generations (Hidayat, 2021).

Fishermen's various observations of the coastal environment relate to natural phenomena that can be analyzed using concepts from physics. Observations of wind direction and sea conditions can be linked to phenomena involving fluids, pressure, and atmospheric dynamics. Observations of waves relate to the concept of mechanical waves, while knowledge of tides and the phases of the Moon can be analyzed using concepts of gravity and the Earth–Moon system. Observing celestial objects can also serve as a context for studying astronomical phenomena. Thus, fishermen's experiences in observing the coastal environment have the potential to be conceptually reconstructed in relation to concepts in physics.

In physics education, everyday life contexts and the local environment can be used to connect abstract physics concepts with students' experiences. Fishermen's knowledge of wind, waves, tides, and celestial phenomena has the potential to serve as a relevant context for learning physics. However, local knowledge cannot be directly equated with validated scientific explanations. Therefore, a systematic conceptual reconstruction is needed to distinguish empirical evidence from informants, the community's experiences and cultural meanings, and relevant concepts in physics.

Although research on local knowledge and disaster preparedness has advanced, studies that specifically document the knowledge of fishermen along the Puger Coast and explicitly analyze its connection to concepts in physics still need to be developed. Studies on the local knowledge of coastal communities have, for the most part, focused on local wisdom as part of adaptation and mitigation strategies, whereas systematic mapping of communities' empirical observations to physical concepts and their potential as a context for physics education remains limited. Therefore, a study is needed that not only documents the forms of local knowledge among fishermen but also analyzes the relationship between community experiences, environmental phenomena, physical concepts, and the meaning of preparedness

Based on this gap, this study aims to explore the forms of local knowledge among fishermen in the Puger Coast in observing environmental phenomena and analyzing their significance in the context of disaster preparedness. Furthermore, the research findings were conceptually mapped to identify their connections to relevant physics concepts as well as their potential as a context for physics learning and disaster literacy. Specifically, this study addresses two questions: (1) How do Puger fishermen interpret their knowledge of and observations regarding the environment—including wind, waves, tides, and celestial phenomena—in the context of safety at sea and disaster preparedness?; and (2) how can this local knowledge be reconstructed into relevant physics concepts and potentially used as a context for physics education and disaster literacy?. This study does not quantitatively assess the effectiveness of instruction or improvements in preparedness; rather, it provides an empirical basis for the development of contextual physics learning resources rooted in the experiences of coastal communities.

METODE

This study employs a qualitative approach with a descriptive research design. This approach was chosen to understand the experiences, knowledge, and perspectives of coastal communities regarding astro-oceanographic phenomena, disaster risks, and the values of local wisdom within the Petik Laut tradition. Qualitative descriptive research allows researchers to describe phenomena based on informants' experiences in their natural environment in the field (Busetto *et al.,* 2020). This study was conducted in the coastal area of Puger Beach, Jember Regency, East Java, with data collection taking place on June 25 and 30, 2025.

Informants were selected using purposive sampling based on their involvement, experience, and knowledge relevant to the research focus (Campbell *et al.,* 2020). The informants consisted of ten individuals: seven senior fishermen with more than 20 years of seafaring experience, two young fishermen who are still actively fishing, and a community leader who understands the history, meaning, and values of the Petik Laut tradition. The selection of informants took into account their ability to provide relevant and in-depth information regarding sea conditions, weather changes, natural signs, potential disasters, and the Petik Laut tradition (Campbell et al., 2020; Hennink & Kaiser, 2022).

Data were collected through semi-structured interviews, field observations, and documentation. Interviews were conducted in person using a guide that covered tidal patterns, wind direction, lunar phases, weather changes, natural signs related to potential disasters, as well as the history and significance of the Petik Laut tradition. Prior to the interviews, the researcher explained the purpose of the study and sought the informants' consent to participate and to record the interviews. Consent was given verbally (verbal consent). The interviews were recorded and transcribed verbatim to serve as the basis for analysis. Observations were conducted to monitor coastal environmental conditions and fishermen's activities, while documentation served as supporting data (Busetto *et al.,* 2020).

Data analysis involved repeatedly reviewing the transcripts and field notes, followed by coding relevant information. Codes sharing similar meanings were grouped into categories and compared across informants to identify patterns, which were subsequently developed into themes. The themes were reviewed by comparing them with data from interviews, observations, and documentation. The results of the analysis were used to identify the connections between astro-oceanographic phenomena, disaster potential, and the local wisdom of "Petik Laut" with relevant physics concepts as the basis for contextual physics learning (Braun & Clarke, 2021; Miles *et al.,* 2014).

Data validity was ensured through technical triangulation and member checking. Triangulation was conducted by comparing the results of interviews, observations, and documentation, while member checking involved reconfirming information with informants whenever information was unclear or required further explanation. These steps were taken to enhance the credibility of the research findings (Tong *et al*., 2007).

The researcher serves as the primary instrument in data collection and interpretation. Reflexivity is practiced by distinguishing between the information provided by informants and the researcher's interpretations during the analysis process. The research also adheres to ethical principles by explaining the research objectives and process to informants, granting them the freedom to participate or discontinue the interview, and maintaining the confidentiality of their identities and the information provided (Tong *et al.,* 2007).

FIGURE 1. Research flow of local wisdom exploration based on fishermen's knowledge in Puger Coast.

RESULT

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This study involved ten informants, consisting of seven senior fishermen with more than 20 years of experience at sea, two younger active fishermen, and one community leader who understands the history and significance of the Petik Laut tradition, as summarized in Table 1. Differences in seafaring experience among the informants indicate variations in how they acquire and apply knowledge about sea conditions: senior fishermen generally rely on empirical experience passed down through generations and based on observations made while at sea, whereas younger fishermen have begun using weather forecast apps to determine the timing and location of their fishing trips. To protect the informants' anonymity, names in the Results and Discussion section are referred to using anonymous codes: NS1–NS7 for senior fishermen, NA1–NA2 for younger active fishermen, and TM1 for community leaders.

TABLE 1. Informant Profile (Anonymous Code)

Code	Category	Seafaring Experience	Role in Research
NS1	Senior fisherman	> 20 year	The primary source of knowledge about observing the Moon, the stars, and traditional navigation
NS2	Senior fisherman	> 20 year	Sources of knowledge about waves, wind, and tides
NS3	Senior fisherman	> 20 year	Sources of information on weather signs and potential hazards
NS4	Senior fisherman	> 20 year	A source of knowledge about seasonal calendars, lunar and stellar signs, navigation, and the practice of Petik Laut
NS5	Senior fisherman	> 20 year	A source of knowledge on celestial signs, wave conditions, information technology, and navigation
NS6	Senior fisherman	> 20 year	the primary source of information via digital weather apps
NS7	Senior fisherman	> 20 year	The primary source for explaining the fishermen's long-standing practice of reading the signs of nature before the advent of modern technology
NA1	Active (younger) fishermen	± 4–10 year	Sources of information on the use of digital weather apps (Windy, Wisuki) and responses to changes in the weather
NA2	Active (younger) fishermen	± 4–10 year	Information sources: a combination of direct observations and weather apps

TM1	Community leader	–	Sources of information on the history, significance, and traditions of Petik Laut

The results of this study indicate that Puger fishermen still rely on local knowledge as the basis for determining their fishing activities and for coping with potential dangers at sea. This knowledge is applied by observing the positions of the moon and stars, wind direction, waves, water color, and tides to determine weather conditions and fishing seasons. One practice that has been preserved is the use of the Talu-talu Star as a navigational guide prior to the development of modern navigation technology. This is corroborated by information from senior informant NS4, who mentioned the use of the Morning Star as a time marker, the Libra constellation as an indicator of the south, and the Kerti Star as a sign of a bountiful catch. In addition, natural phenomena such as a halo of light around the Moon are interpreted by other informants, NS5 and NS7, as a sign of large waves. Furthermore, fishermen understand the relationship between the direction of incoming waves, changes in seawater, and monsoon wind patterns with the presence of fish and the safety of going out to sea. This knowledge is gained through experience passed down from generation to generation.

This was further supported by a statement from NA1, a fisherman from Puger, who explained that fishermen still rely on natural signs to predict weather conditions before heading out to sea. NA1 stated that “in the past, fishermen relied on the positions of the moon, stars, and constellations to determine wind direction and strength. One example is the Talu-talu Star, which was used to determine direction and tell time before the use of compasses.” This statement reflects the informant’s personal experience and beliefs based on practices passed down through generations, not indicators that have been scientifically tested by researchers. Nevertheless, NA1 also explained that currently he “relies about 90% more on apps than on traditional methods.” A similar pattern was demonstrated by additional informants NS6–NS7, who utilize digital tools such as social media, WhatsApp groups, cell phones, and two-way radios to monitor weather forecasts and communicate with other fishermen already at sea. This indicates a shift in practices toward the use of digital technology.

In addition to supporting fishing activities, local knowledge also plays a role in fishermen’s preparedness for extreme weather and potential disasters. Before setting out to sea, fishermen observe natural conditions to determine whether to depart. When the weather changes suddenly out at sea, fishermen choose to take shelter behind an island or the mainland until conditions are safe again, rather than forcing their way back to shore. Several informants also explained that a sudden retreat of seawater is believed to be one of the early signs of a potential tsunami, prompting the community to immediately evacuate to higher ground; this interpretation—based on the informants’ beliefs and experiences—and its relationship to official warnings from the BMKG are discussed further in the Discussion section. Some fishermen, including NS7, NA1, and NA2, have been using apps such as Windy and Wisuki, as well as weather forecast information from the BMKG, to supplement their direct observations of sea conditions

The Petik Laut tradition remains an integral part of the lives of the Puger fishing community. Based on interview findings, this tradition is seen as an expression of gratitude to God for the bounty of the sea, as well as a prayer for the fishermen’s safety while at sea. During the Petik Laut ceremony, most fishermen suspend their fishing activities as a sign of respect for this tradition, which has been passed down from generation to generation. TM1 explained that the primary significance of this tradition is gratitude for the abundance of marine resources, while the various offerings used are part of cultural symbols that have been adapted to reflect the religious values of the local community.

This is in line with what was stated by TM1, a community leader in Puger. According to him, the Petik Laut tradition has been passed down from generation to generation and symbolizes gratitude for the people of Puger. TM1 explained that “the purpose of the Puger people holding Petik Laut is to give thanks, because we’ve been given such an abundant blessing without any investment, without us having to feed the fish in any special way. So this is the culmination of the Puger people’s celebration of their gratitude for being granted this extraordinary blessing.” In addition to being an expression of gratitude, this tradition is also preserved through a series of activities involving the community. TM1 also explained that the Petik Laut festivities begin with a cultural parade, followed by a wayang performance

and the offering of ritual gifts to the sea, and are preceded by religious activities such as the completion of the Qur'an recitation (khatmil Qur'an) and collective tahlil prayers with all residents.

The Petik Laut tradition also serves a social function in strengthening bonds among coastal residents through their shared participation in the entire series of cultural activities. Although some young fishermen do not yet fully understand the philosophical significance of each procession, they still view Petik Laut as a cultural identity of the Puger community that must be preserved. These findings indicate that the Petik Laut tradition serves not only as a cultural ritual but also as a means of preserving local values that strengthen solidarity among coastal communities.

Theme and Evidence Matrix

To clarify the evidence trail from informant quotes to research themes, Table 2 summarizes the main themes along with representative evidence, informant codes, and the types of evidence, distinguishing between observations, participants' beliefs or experiences, and the researcher's interpretations..

TABLE 2. Matrix of Themes and Evidence

Theme	Evidence/Representative Quotes	Informant Code	Types of Evidence
Traditional celestial navigation	*"...in the past, fishermen relied on the positions of the moon, stars, and constellations to determine the direction and strength of the wind… The Talu-talu star was used to determine direction and tell time before the compass was invented."*	NA1 (supported by NS4)	Participants' experiences/beliefs
Observing natural signs and fishing seasons	Observations of the positions of the Moon and stars (the Morning Star, Libra, and Kerti), wind direction, wave characteristics, changes in the color of the seawater, and tides to determine when to set sail.	NS1–NS7	Field observations & empirical practice
The Shift to Digital Technology	*"...about 90% rely more on apps than on traditional methods."*	NA1	Participants' self-reports
Natural signs as indicators of a tsunami	A sudden retreat of the seawater is believed to be an early warning sign of a tsunami, prompting residents to immediately evacuate on their own to higher ground.	NA1, NS1–NS3	Participants' beliefs (not yet scientifically validated)
A combination of direct observation and digital information	The use of the Windy and Wisuki apps, BMKG bulletins and information, social media, WhatsApp groups, cell phones, and two-way radios to supplement direct ocean observations.	NS4–NS7, NA1–NA2	The researcher's observations of the informants' practices
The Meaning of "Petik Laut" as an Expression of Gratitude	*"...the purpose of the Puger people in holding the Petik Laut ceremony is to give thanks for having been blessed with such abundant provisions without having to invest any capital..."*	TM1	Participants' interpretations/beliefs

The Petik Laut Tradition Series	The holding of a cultural parade, a wayang performance, the offering of ritual offerings, and religious activities such as the completion of the Qur'an and collective tahlil with the community.	TM1	Observation and Documentation of Traditions
The social function of Petik Laut as a unifying force for solidarity	The collective participation of residents in the entire series of cultural ceremonies strengthens social interaction and solidarity among coastal residents.	Researcher	The researcher's interpretation (based on observations of community participation)

DISCUSSION

Local Ecological Knowledge of Fishermen on the Puger Coast

Research findings indicate that fishermen in the Puger coastal region possess local knowledge that has developed through long-term interaction with the marine environment. This knowledge includes observations of wind direction, the positions of the Moon and stars, constellations, wave characteristics, changes in seawater color, tidal conditions, and seasonal changes. These observations are used to determine fishing activities and assess whether sea conditions are suitable for going out to sea. This knowledge is primarily acquired through experience and intergenerational transmission, rather than through formal education.

Research findings also indicate differences in the application of local knowledge across generations. Younger fishermen are beginning to use digital weather apps, such as Windy and Wisuki, while some older fishermen still rely more heavily on observations of the Moon, stars, tides, and marine environmental conditions. These differences do not indicate that traditional knowledge has been completely abandoned. On the contrary, the findings suggest a complementary pattern of use, in which digital information is used alongside direct observations of marine environmental conditions. NA1, for example, explained that apps are used to monitor wind and waves, but observations of environmental conditions remain a key consideration when making decisions at sea. Meanwhile, NS3 noted that he still observes the moon and stars and is not yet accustomed to using weather forecasting apps.

This pattern can be understood as a form of Traditional Ecological Knowledge (TEK)—knowledge that has evolved through the ongoing interaction between communities and their surrounding environment. In the context of Puger, local knowledge is not only related to cultural practices but also serves a practical function in understanding environmental changes and supporting day-to-day decision-making. This finding aligns with the view that traditional ecological knowledge can serve as a source of adaptation for communities that interact intensively with the natural environment (Witharana *et al*., 2025). However, the findings of this study do not indicate that all fishermen possess the same knowledge or that all interpretations of environmental signs have been scientifically validated.

One key finding relates to the use of celestial bodies for navigation and environmental interpretation. NS2 explained that observations of the Moon and stars are still practiced, including the use of specific stars as references for time or direction. NA1 also explained that the Talu-talu Star was once used as a directional reference before the widespread adoption of modern navigation tools. These findings indicate that observations of celestial bodies are part of a knowledge system based on fishermen's experience. From a physics education perspective, these observations can serve as an authentic context for discussing the positions of celestial bodies, apparent motion, orientation, and navigation—without assuming that the local terms used by fishermen automatically correspond to scientific astronomical classifications.

Local Knowledge in Building Disaster Preparedness

Further research findings indicate that knowledge of marine environmental conditions plays a role in fishermen's decision-making before and during fishing activities. Observations of wind, waves, tides, sky conditions, and other environmental changes are used to determine whether fishing trips can proceed and how fishermen respond when conditions change. When weather conditions change suddenly at sea, NA1 described several types of responses, such as reducing the boat's speed, maintaining the boat's stability, and avoiding areas considered more dangerous. These practices demonstrate experience-based responses to environmental uncertainty but cannot be directly equated with standardized disaster response protocols.

Fishermen's understanding of tsunami hazards also reveals a connection between local experience and disaster preparedness. Informants identified a sudden retreat of seawater as one of the signs associated with a potential tsunami and noted that evacuating to higher ground is the appropriate response. This knowledge is important as part of the community's awareness of tsunami hazards. However, the sign of the sea water receding must be distinguished from scientifically validated tsunami warning systems. The sea water may recede before the arrival of a specific tsunami, but not all tsunamis produce the same receding pattern. Therefore, local observations should be understood as one component of hazard awareness and not as a substitute for official warnings or established evacuation procedures (Marliana *et al.,* 2026).

This distinction is important because decisions directly related to safety must continue to be based on reliable information sourced from official agencies. Research findings indicate that fishermen's local observations coexist with information from the BMKG and weather apps. TM1 explained that disaster-related information has been disseminated by the government, and the community is increasingly gaining access to information that enables them to anticipate potential hazards. The existence of these various information sources suggests that preparedness in Puger is shaped through the interaction between local experience and formal information systems.

The community's interpretation of environmental signs also needs to be considered carefully. For example, NA1 noted that stars appearing to twinkle rapidly are associated with strong winds. Similarly, a halo of light around the Moon is understood as a sign related to changes in weather conditions. In this study, these statements are presented as the informants' interpretations of environmental phenomena, not as validated meteorological indicators. The significance of these findings lies in how fishermen construct meaning based on repeated environmental observations. To determine the reliability and predictive power of each of these signs, further scientific research is still needed.

Thus, local knowledge can be understood as a resource that supports disaster preparedness through fishermen's ability to recognize environmental changes and adjust their activities accordingly. However, this qualitative study did not measure the effectiveness of these practices in reducing disaster-related losses or improving community preparedness levels. Therefore, the research results only indicate the potential contribution of local knowledge to community preparedness; they do not prove a causal increase in preparedness (Ahmad, 2025).

Local Wisdom as Social Capital and Its Integration with Modern Information

Research findings indicate that local knowledge in Puger is preserved not only at the individual level but also through social interactions among members of the fishing community. Knowledge regarding wind, waves, celestial observations, tides, fishing seasons, and responses to changing sea conditions is passed down through experience and intergenerational interactions. Senior fishermen play a role in preserving experience-based knowledge, while younger fishermen are beginning to incorporate digital information sources into their fishing practices. This intergenerational exchange highlights an important social dimension in the sustainability of local knowledge.

The integration of traditional knowledge and modern information is particularly evident in the practices of younger fishermen. The use of Windy and Wisuki provides access to information on wind and waves, while BMKG data serves as an additional source for weather and disaster information. At the same time, fishermen can still compare this information with their direct observations of sea conditions. This pattern suggests that local and scientific information systems are not always at odds. Both can serve different functions in the decision-making process (Aguirre *et al.,* 2026).

From a disaster preparedness perspective, this integration aligns with a community-based approach that positions local knowledge as a key component of community capacity, while also

emphasizing the importance of access to formal disaster information (Palma *et al.,* 2025). However, this study does not prove that the combination of local knowledge and digital information is more accurate or more effective than the use of either information source separately. The qualitative data obtained only indicate that fishermen use various information sources when facing uncertain environmental conditions.

The Petik Laut tradition adds another social dimension. The research findings indicate that the community views this tradition primarily as an expression of gratitude for marine resources and as a cultural practice linked to hopes for safety. Its observance involves various collective activities, including cultural processions, performances, religious ceremonies, and the offering of ritual gifts. Community involvement in these activities strengthens social interaction while preserving the cultural identity of the Puger community. Thus, "Petik Laut" should not be positioned as a direct disaster mitigation technology (Novita *et al.,* 2025). Its contribution is more appropriately discussed in the context of social cohesion, cultural sustainability, and the community's collective values in building relationships with the marine environment. This distinction is important because cultural significance and disaster preparedness mechanisms are two interrelated but not identical dimensions.

Reconstructing Local Knowledge into Physics Concepts and the Context of Disaster Literacy

One of the main implications of the study's findings for physics education is the potential to reconstruct fishermen's environmental knowledge into a context for learning physics. Various observations identified in this study relate to phenomena that can be linked to physics concepts, particularly gravity, waves, fluid phenomena, and astronomy. Such reconstruction can provide a local context for physics learning while maintaining a distinction between the community's empirical knowledge and scientific explanations.

The relationship between tides and observations of the Moon is one example. Fishermen pay attention to tidal conditions and the Moon's position in their daily activities. These phenomena can be linked to the concept of gravitational interactions between the Earth, the Moon, and the Sun. In physics education, observations of tides can serve as a starting point for discussing gravitational interactions and the mechanisms behind tides. The purpose of this approach is not to claim that fishermen explain tidal phenomena using Newton's theory of gravity, but rather to connect authentic local observations with the scientific concepts studied in physics.

Fishermen's observations of waves can also serve as a context for discussing mechanical waves. Local descriptions of wave conditions can be linked to the concepts of wave height, period, propagation, and the relationship between wave characteristics and coastal conditions. The phenomenon of tsunamis can further be used as a context for disaster literacy, so that students can understand that tsunamis are ocean wave phenomena with characteristics different from the ocean waves typically observed in daily life.

Observations of wind direction and changes can also serve as a context for discussing fluid motion and environmental dynamics. In the classroom, these local observations can serve as a starting point for inquiry-based activities that compare fishermen's descriptions with meteorological data. This approach enables students to understand how an observation can be developed into an explanation and how various sources of information can be compared and evaluated.

Navigation using celestial objects provides another context for physics education. The use of Bintang Talu-talu and other stars as references for direction or time can be linked to celestial observations, apparent motion, orientation, and astronomical navigation. However, local names such as the Talu-talu Star should be preserved as terms used by the community and should not automatically be equated with specific constellations or astronomical classifications if such equivalences are not supported by data from informants or astronomical sources. The relationship between local findings, physics concepts, disaster preparedness, and potential learning applications can be summarized as shown in Table 3 below.

TABLE 3. The Relationship Between Local Knowledge, Physical Concepts, and the Meaning of Disaster Preparedness

Local Observations/Knowledge	Relevant Findings	Physics Concepts	The Importance of Preparedness	Potential Applications of Learning
Observation of Tides and the Moon	Fishermen pay attention to the tides and the moon before heading out to sea	Gravitational and tidal interactions	Helps you assess sea conditions before engaging in activities	The Legal Context of Newton's Law of Gravity and Tides
Wave observation	Fishermen monitor wave conditions and adjust their fishing activities accordingly	Mechanical waves and wave characteristics	Helps identify potentially hazardous ocean conditions	Context of the Properties of Waves and Tsunamis
Observation of wind direction and changes in wind	Fishermen monitor the direction and changes in wind conditions	Fluid Dynamics and Atmospheric Processes	Helps determine the timing and conditions of a voyage	The Context of Wind and Fluid Phenomena
Observing the Moon and Stars	Celestial bodies are used as environmental or navigational reference points	The Motion of Celestial Bodies and Astronomy	Helping with environmental orientation and interpretation	Astronomy and Navigation Context
Talu-talu Star	Traditionally used as a guide for direction	Astronomical navigation	Helps determine one's orientation at sea	The Context of Local Knowledge and Astronomy
A sudden drop in sea level	Informants linked the sudden receding of the tide to the possibility of a tsunami	Long waves and tsunami processes in coastal areas	Raising awareness of the potential danger of tsunamis	The Context of Disaster Literacy and Tsunamis

Table 3 shows that the educational value of the research findings lies primarily in their potential as a contextual entry point for physics learning and disaster literacy. This study does not demonstrate that the use of such contexts can improve students' conceptual understanding or preparedness, as the research did not involve any instructional interventions or measurements of learning outcomes. Therefore, the research findings can serve as a conceptual foundation for developing physics teaching materials or learning activities based on local contexts, which still require a process of design, expert validation, and classroom testing.

This contextual approach is also relevant for the development of science literacy, as students can be guided to compare local observations, scientific explanations, and official disaster information. For example, students can analyze fishermen's observations of waves and then compare them with the characteristics of waves as described by scientific concepts, or compare the community's interpretations of environmental signs with meteorological information from the BMKG. These activities can help students distinguish between empirical observations, cultural interpretations, scientific explanations, and evidence-based safety information.

Implications for Contextual Physics Education and Disaster Literacy

The research findings indicate that the Puger coastal environment provides a rich context for integrating physics concepts with disaster literacy. Local knowledge should not be viewed as a substitute for scientific knowledge but can serve as a starting point for investigating, comparing, and evaluating evidence. This approach aligns with contextual learning, as students can begin their learning from phenomena closely tied to their social and geographic environment. The identified potential applications for learning include the interplay of gravity and tides, the characteristics of waves and tsunamis, wind and fluid phenomena, and celestial navigation—all of which can be developed through digital interactive learning media (Bahari *et al.,* 2023). These contexts can also highlight the interconnections between physics, earth sciences, astronomy, the environment, and disaster preparedness. However, all of these potentials represent educational implications derived from qualitative findings, not the results of measurements of learning effectiveness (Muhlisah and Arpin, 2021).

As a follow-up, the knowledge of Puger fishermen can serve as the foundation for developing physics learning resources based on local contexts, such as the development of integrated digital physics modules incorporating local coastal wisdom from Jember (Midroro *et al.,* 2022). These learning resources can take the form of case-based learning, inquiry-based activities, digital learning media, or disaster literacy activities. Before implementation, the reconstruction of physics concepts, the accuracy of local knowledge representations, cultural appropriateness, and the effectiveness of the learning resources must be examined through expert validation and empirical classroom research. Thus, this study's contribution to physics education lies in identifying locally meaningful environmental phenomena that have the potential to be used as contexts for physics learning and disaster literacy. This study provides a conceptual foundation for the development of contextual physics learning based on local wisdom; however, it does not yet provide evidence regarding its effectiveness in terms of student learning outcomes or disaster preparedness.

CONCLUSION

This study shows that fishermen along the Puger coast possess local knowledge that has developed through long-term experience and interaction with the marine environment. This knowledge includes observations of wind direction, waves, tides, the positions of the Moon and stars, changes in water color, and signs of changing weather. This knowledge is used to determine the timing and safety of fishing activities and forms part of how fishermen respond to risky environmental conditions. As technology advances, local knowledge has not been entirely abandoned but is increasingly being integrated with digital information such as weather apps and data from the BMKG. Local knowledge also holds potential for supporting disaster preparedness, particularly through the ability to recognize environmental changes and make decisions based on experience. However, findings regarding natural signs—including the receding of seawater associated with tsunamis—represent the informants' experiences or interpretations and cannot be considered a substitute for official early warning systems. Meanwhile, the Petik Laut tradition plays a role in preserving cultural identity, a sense of gratitude, and social cohesion among coastal communities, but it cannot be directly categorized as a disaster mitigation technology.

Further research findings indicate that fishermen's local knowledge has conceptual links to several physics concepts, such as the interaction of gravity and tides, mechanical waves and tsunamis, fluid and wind phenomena, as well as astronomy and celestial navigation. This mapping highlights the potential of Puger's local knowledge as a context for physics learning and disaster literacy that is closely tied to students' daily lives. Thus, this study provides an empirical and conceptual foundation for the development of physics learning resources based on local coastal wisdom. However, this study has not yet tested the effectiveness of applying this context on students' learning outcomes or preparedness; therefore, further research is needed through the development, validation, and testing of classroom instruction.

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