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Contextual Science Learning Through Mangrove Ecosystems: A Needs Analysis for Elementary Education

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ABSTRACT

This study analyzes elementary school learning needs based on the local potential of the Tuban Mangrove Center to strengthen students' scientific literacy in ecosystem topics. This study was motivated by the persistently low level of students' scientific literacy, largely attributed to concept-oriented instruction that insufficiently contextualizes learning within authentic real-world situations. A qualitative needs analysis design was employed involving six elementary school teachers and three purposively selected mangrove center managers. Data were gathered through semi-structured interviews, classroom observations, and analysis of instructional documents. Instrument validity was established through expert judgment, while data trustworthiness was enhanced using source and technique triangulation. Data analysis followed the Miles and Huberman interactive model comprising data reduction, data display, and conclusion drawing. The findings reveal that science learning is largely textbook-oriented and has not effectively utilized the environment as a learning resource. Limited laboratory facilities and the absence of contextual teaching materials contribute to low authentic learning experiences. Although the Tuban Mangrove Center has strong potential as a natural laboratory for scientific observation and investigation, its use remains unsystematic. This study highlights the need for structured, contextual learning designs based on local potential to enhance students' scientific literacy and ecological awareness.

ARTICLE INFORMATION

Keywords:
contextual learning; ecosystem learning; local potential; scientific literacy

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INTRODUCTION

Scientific literacy has become one of the essential competencies in twenty-first-century education because it enables students not only to understand scientific concepts but also to apply scientific reasoning in addressing problems encountered in daily life. Scientific literacy encompasses the ability to explain scientific phenomena, evaluate and design scientific inquiry, and interpret evidence-based data for decision-making related to natural and social environments (Pujiati, 2019; Retno et al., 2025). In the context of elementary education, scientific literacy is particularly important because it forms the foundation for students' critical thinking, environmental awareness, and problem-solving abilities from an early age. However, the development of scientific literacy among Indonesian students remains a significant challenge. The results of the 2022 Programme for International Student Assessment (PISA) revealed that Indonesia's science literacy score declined to 383 from 396 in 2018 and remained substantially below the OECD average (Deta et al., 2025). This

condition indicates that science learning in Indonesia has not yet effectively facilitated students in connecting scientific concepts with authentic real-life contexts.

Empirical evidence from elementary school classrooms further demonstrates that science learning is still predominantly teacher-centered and oriented toward conceptual memorization. Learning activities often emphasize textbook completion, factual recall, and conventional assessment practices, while opportunities for inquiry, observation, experimentation, and contextual exploration remain limited (Aydin, 2020; Ramli et al., 2021). Several studies reported that elementary students experience difficulties in interpreting scientific phenomena, relating concepts to environmental issues, and applying scientific knowledge to solve contextual problems (Hernawati et al., 2019; Sholahuddin, 2021). Classroom observations in several elementary schools in Tuban Regency also indicate that ecosystem topics are generally taught through lectures and visual media without direct engagement with natural environments surrounding students (Fairhurst et al., 2023; Shofiyah et al., 2022). Consequently, students tend to perceive science as abstract and disconnected from their daily experiences, resulting in low learning motivation and limited ecological awareness.

One educational approach considered effective for strengthening scientific literacy is context-based learning through the integration of local potential. This approach emphasizes the use of local environments and socio-cultural contexts as meaningful learning resources that enable students to construct scientific understanding through direct interaction with real phenomena (Abdullah et al., 2025; Ardan, 2016). Contextual science learning has been shown to improve conceptual understanding, inquiry skills, and students' environmental responsibility because learning experiences become more authentic and relevant to students' lives (Iswahyudi et al., 2019). For elementary school students, contextual learning is particularly important because children at this developmental stage understand concepts more effectively through concrete experiences rather than abstract explanations. One local potential that possesses strong educational value is the mangrove ecosystem. Mangrove ecosystems have important ecological functions, including preventing coastal abrasion, maintaining biodiversity, serving as nursery habitats for marine organisms, and acting as significant carbon sinks in mitigating climate change (Naibaho et al., 2022; Suriadi et al., 2024). In addition to their ecological functions, mangrove ecosystems provide rich contextual learning resources for science education, especially in topics related to ecosystems, biodiversity, environmental conservation, adaptation, and interactions among living organisms. Through direct observation activities, students can investigate ecological relationships, identify environmental problems, and develop scientific reasoning based on authentic environmental data (Oprasmani et al., 2020).

The Tuban Mangrove Center represents one of the local conservation areas with substantial potential to support contextual science learning in elementary schools. The conservation area contains diverse mangrove species, coastal biota, and environmental conservation activities that can serve as authentic learning resources for ecosystem materials. However, preliminary observations revealed that the educational utilization of the Tuban Mangrove Center remains suboptimal. Interviews with mangrove center managers indicated that visits from elementary schools are still dominated by recreational activities rather than structured educational programs integrated with science learning objectives. Furthermore, most teachers have not yet developed learning designs that systematically integrate mangrove ecosystems into classroom instruction. Limited teaching materials, lack of contextual learning modules, and insufficient teacher knowledge regarding outdoor environmental learning were also identified as major constraints in implementing local potential-based science learning. Previous studies have demonstrated that environment-based and local potential-based science learning can improve students' conceptual understanding, scientific literacy, and environmental attitudes (Herdiana & Sunarno, 2021; Hernawati et al., 2019; Sholahuddin, 2021).

Environmental learning activities involving direct interaction with natural phenomena were found to strengthen observation skills, scientific reasoning, and problem-solving competencies (Abdullah et al., 2025; Suryawati & Osman, 2018). Moreover, ecosystem-based learning utilizing natural environments as learning laboratories has been shown to increase students' motivation and engagement in science learning (Djarwo et al., 2025). Nevertheless, most existing studies primarily focus on implementing environmental learning models in general contexts and have not specifically explored integrating mangrove conservation areas as contextual learning resources in elementary science education.

In addition, studies investigating the integration of mangrove ecosystem potential into elementary science learning are still limited, particularly at the needs analysis stage. Needs analysis is a critical initial phase in educational development research because it identifies actual classroom conditions, teacher competencies, student learning needs, and environmental resources that can support contextual learning design. Without comprehensive needs analysis, the development of local potential-based learning may not align with the real conditions and challenges encountered in schools. Furthermore, there is still limited research specifically examining the educational potential of the Tuban Mangrove Center as a contextual science learning resource for elementary schools in Tuban Regency.

Therefore, this study aims to analyze the learning needs of elementary schools regarding the utilization of the Tuban Mangrove Center as a contextual science learning resource to strengthen students' scientific literacy in ecosystem topics. The study specifically examines existing science learning practices, teachers' needs and challenges, the availability of contextual learning resources, and the educational potential of the mangrove ecosystem for elementary science instruction. In addition, this research explores how environmental-based learning experiences can support students in understanding scientific concepts through direct observation and authentic interaction with natural phenomena. The study also investigates teachers' readiness to integrate local environmental contexts into classroom learning activities. By conducting a comprehensive needs analysis, this research seeks to identify gaps between current instructional practices and the demands of scientific literacy-oriented learning. The findings are expected to provide empirical evidence regarding the relevance of mangrove ecosystems as contextual learning environments for elementary students. Furthermore, the results may contribute to the development of innovative and meaningful science learning designs rooted in local environmental potential. Ultimately, this study is expected to support the improvement of elementary students' scientific literacy competencies while simultaneously fostering environmental awareness and sustainable conservation attitudes from an early age.

METHOD

This study employed a qualitative descriptive design with a needs analysis approach to examine the potential utilization of the Tuban Mangrove Center as a contextual science learning resource for strengthening elementary students' scientific literacy on ecosystem topics. The research was conducted in six elementary schools located in Jenu District, Tuban Regency, East Java, Indonesia, which are situated near the Tuban Mangrove Center conservation area. A qualitative approach was selected to explore in depth the actual conditions of science learning, teachers' needs, and the educational potential of the surrounding environment. The participants consisted of six fifth-grade elementary school teachers and three community leaders managing the Tuban Mangrove Center. Participants were selected purposively based on their direct involvement in science learning and mangrove conservation activities.

Data were collected through semi-structured interviews, classroom observations, and document analysis to obtain comprehensive information regarding science learning practices and the integration of local environmental resources. Semi-structured interviews were conducted with

teachers and mangrove center managers to explore learning challenges, contextual learning opportunities, and the utilization of mangrove ecosystems in science instruction. Classroom observations focused on identifying teaching practices, student engagement, inquiry activities, and the use of contextual learning approaches during ecosystem instruction. In addition, document analysis was carried out on curriculum documents, teaching modules, lesson plans, and teaching materials used by teachers to examine their alignment with scientific literacy-oriented learning. The combination of these techniques enabled the researchers to obtain rich and contextualized data from multiple perspectives.

The research instruments consisted of interview guidelines, observation sheets, and document analysis protocols developed based on indicators of scientific literacy and contextual science learning. The instruments were validated by experts in science education and elementary learning to ensure content relevance, clarity, and appropriateness for the study's objectives. Revisions were made based on expert feedback before the instruments were implemented in the field. Furthermore, the trustworthiness of the data was strengthened through source triangulation and technique triangulation to enhance the credibility and consistency of the findings. These procedures were conducted to ensure that the collected data accurately reflected the actual conditions of science learning in elementary schools.

Data analysis followed the interactive model proposed by Miles et al. (2014), which includes data reduction, data display, and conclusion drawing. In the data reduction stage, the researchers selected, categorized, and organized relevant information obtained from interviews, observations, and document analysis. The reduced data were then presented in descriptive and thematic forms to facilitate the identification of patterns related to science learning practices, contextual learning barriers, and the educational potential of the mangrove ecosystem. Conclusions were drawn continuously throughout the research process by interpreting relationships among categories and verifying findings through repeated examination of the data. This analytical process enabled the study to generate comprehensive findings regarding the learning needs of elementary schools and the integration of mangrove ecosystems into contextual science learning to strengthen students' scientific literacy and ecological awareness.

RESULTS AND DISCUSSION

Interviews with three community leaders managing the Tuban Mangrove Center indicate that the mangrove ecosystem not only serves an ecological function but also supports the social and economic life of coastal communities. The research subjects emphasized that the presence of mangroves can reduce the impact of coastal abrasion and maintain coastal stability, thus providing a sense of security for the surrounding community. Furthermore, this ecosystem serves as a source of livelihood, particularly for fishermen who depend on the marine life in the mangrove area. The Tuban Mangrove Center is also a conservation area, functioning as a nature tourism area and a center for coastal and marine environmental education in Tuban Regency.

The Tuban Mangrove Center boasts a high level of biodiversity, both flora and fauna. A relatively high diversity index indicates that the Tuban Mangrove Center area is suitable for supporting bird life, due to the availability of food sources, habitats, and other factors (area size and climate). The high diversity index in the Tuban Mangrove Center area may be due to the area's abundant food supply for almost all bird species. Birds in the area also utilize the vegetation for nesting and resting. Three bird species are most commonly found at the Mangrove Center: Collocalia esculenta, Bubulcus ibis, and Egretta garzetta. Furthermore, 12 other vegetation species are frequently used by birds for nesting, roosting, and foraging: Rhizophora mucronata, Bruguiera gymnorrhiza, Pandanus odoratissima, Ceiba

pentandra, Hibiscus tiliaceus, Muntingia calabura, Tectona grandis, Calotropis gigantea, Acacia constricta, Acacia auriculiformis, Manilkara kauki, and Casuarina equisetifolia.

The Tuban Mangrove Center has great potential to serve as a natural laboratory for elementary school students. However, interviews indicate that the use of the Mangrove Center as a learning resource is still not optimal. Limited integration and collaboration between schools and administrators, as well as the lack of a systematic learning design based on local potential, are major obstacles to implementing mangrove-based learning. The Tuban Mangrove Center has significant potential to strengthen elementary school students' scientific literacy, not only in cognitive aspects but also in affective and contextual aspects. Therefore, the integration of mangrove ecosystems into science learning needs to be systematically designed to bridge the gap between scientific concepts and students' environmental realities.

Interviews with six fifth-grade teachers indicate that learning practices are still dominated by the implementation of the existing curriculum, despite a policy shift toward the Independent Curriculum, which emphasizes differentiated, contextual, and environmentally based learning. Efforts to integrate local wisdom into learning have begun, but remain sporadic and have not been systematically designed into learning tools, including teaching modules, materials, and learning activities. The local wisdom presented tends to be limited to general cultural aspects that are informative, without deeply connecting it to the science concepts students are learning.

The utilization of natural resource potential in the surrounding environment, particularly the Tuban Mangrove Center ecosystem, has not been optimally integrated into learning. Teachers still show a high dependence on existing textbooks, resulting in learning that tends to be textual and lacks contextual learning experiences. This finding is reinforced by observations indicating a lack of contextual teaching materials that specifically accommodate local potential as learning resources. This situation indicates a gap between the demands of the curriculum, which prioritizes context-based learning, and field-based learning practices that are still oriented towards conceptual delivery. Nevertheless, most teachers have a positive perception of the importance of integrating local wisdom and environmental potential in learning. They stated that learning that links material to the real context around students can increase the meaningfulness of learning, as demonstrated by increased motivation, curiosity, and active involvement of students in the learning process. Therefore, it is necessary to develop learning designs that systematically integrate local potential, particularly the mangrove center ecosystem in Tuban, into science learning in elementary schools, so that it not only supports the achievement of curriculum competencies but also sustainably strengthens students' scientific literacy and ecological awareness. This stage involved analyzing the existing curriculum in fifth-grade elementary schools to determine which lessons could integrate the potential of the mangrove ecosystem. This analysis ensured that the teaching materials developed were aligned with the current curriculum and supported the achievement of expected competencies, including strengthening scientific literacy. The results are presented in Table 1.

Table 1. Analysis of Learning Outcomes

Element Learning	Competence Learning	Objective
Understanding of Science and Technology	Analyze the connection between biotic and abiotic components, as well as their influence on the ecosystem.	Understand the connection between biotic and abiotic components, as well as their influence on the ecosystem.
Skills Process	Observing Questioning and Predicting Planning and Doing Investigation. Processing as well as Analyzing Data and Information. Evaluating and Reflecting. Communicating Results.	Create problem-based solutions based on issues related to local, national, or global ecosystems, using appropriate process skills.

Based on the analysis of learning outcomes, learning objectives and learning objective indicators can be determined. The learning objectives and learning objective indicators are as shown in Table 2.

Table 2. Analysis of Learning Objectives, Learning Objective Indicators and Indicators of Science Literacy

Learning objectives	Learning Objective Indicators	Indicator Science Literacy
Understand the connection between biotic and abiotic components, as well as their influence on the ecosystem.	Through activity observing the mangrove environment, participants can identify biotic and abiotic components appropriately.	Explain phenomena in a scientific way (*Content Knowledge*)
	Through discussion groups, participants can classify the roles of producers, consumers, and decomposers in the mangrove ecosystem.	Explain phenomenon in a scientific way (*Content Knowledge*)
	Through analysis of pictures or videos, participants can explain the connection and dependence between biotic and abiotic components.	Scientifically explain the phenomenon.
	Through activity data literacy (tables/graphs), participants can explain the influence of changes in one component on the balance of the mangrove ecosystem.	Interpreting data and evidence scientifically (*Procedural Knowledge*)
	Through case studies of mangrove damage, participants become capable of predicting impacts on the environment and the food chain.	Making predictions based on proof (*Epistemic Knowledge*)

Learning objectives	Learning Objective Indicators	Indicator Science Literacy
Create solutions to problems based on issues local, national, or global related to ecosystems, with processes related to skills.	Through analysis of the mangrove ecosystem problem, participants are educated and capable of designing simple solutions based on observation results, data, and scientific evidence in a systematic way.	Evaluate and design scientific investigations (*Procedural Knowledge*)

In addition, the researchers analyzed ecosystem materials presented in the revised edition of the fifth-grade Phase C Elementary Science textbook published by the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia. Based on this analysis, a conceptual framework of the ecosystem topic was developed to support the preparation of contextual teaching materials. The concept map encompassed major ecosystem concepts, including biotic and abiotic components, interactions among ecosystem components, energy flow, and environmental issues related to ecosystem balance. This stage was conducted to ensure that the developed materials were conceptually accurate, systematically organized, and aligned with curriculum learning outcomes. Furthermore, the analysis aimed to establish coherent relationships among concepts to facilitate students' scientific understanding through contextual learning experiences. The results of the ecosystem concept analysis are presented in Table 3.

Table 3. Analysis Ecosystem Material Concept

Main Concept	Subconcepts	Description Conceptual	Concept Hierarchy	Depth of Material	Relationships Between Concepts
Ecosystem	Understanding ecosystem	Ecosystem as a system of interaction between living organisms and the environment, not life	Draft base	Conceptual general	Become base all over discussion
Component Ecosystem	Component biotic	Producers, consumers levels I–III, and decomposers based on role in system trophic.	Core concept	Deep enough for elementary school level	Become base chains and nets food
Component Ecosystem	Component abiotic	Sunlight, water, land, air as factors supporting life	Core concept	Descriptive	Supports the process of photosynthesis and life

Main Concept	Subconcepts	Description Conceptual	Concept Hierarchy	Depth of Material	Relationships Between Concepts
Relationship between components	Chain food	Connection eat and be eaten linearlyin something ecosystem	Development draft	Concrete and applicable	Basis of formation nets food
Relationship between components	Nets food	Relatedness several food chains in one ecosystem	Draft complex	Analytical simple	Describe system ecology in a way intact
Energy Flow	Source of energy and energy transfer	Energy comes from the sun and moves through the process of eating and being eaten.	Draft advanced	Cause and effect	Related to the roles of producers and consumers
Energy Flow	Pyramid food	Representation of the amount of energy in each trophic level	Visual representation	Visual-quantitative simple	Explain decrease energy each level
Balance Ecosystem	Stability ecosystem	Dependence between components to maintain balance	Integrative	Analytical	Connected with net food and energy flow
Problems Environment	Disturbance ecosystem	Fire in forests, hunting, changing populations, human activity	Application contextual	Contextual	Show impact of disturbance to system

Based on the concept analysis, the ecosystem material was structured hierarchically, beginning with fundamental ecosystem concepts, followed by ecosystem components consisting of biotic and abiotic elements, relationships among components through food chains and food webs, energy flow and food pyramids, and finally ecosystem balance and environmental problems. This conceptual sequence reflects a progressive flow of thinking from basic understanding toward more complex, systemic, and contextual analysis. The organization of the material was designed to align with the cognitive development characteristics of Phase C elementary students, who are transitioning from the concrete operational stage toward the early stages of formal operational thinking. Therefore, the

hierarchical structure supports students in gradually constructing scientific understanding through contextual and meaningful learning experiences.

The observation aimed to identify the actual condition of facilities and infrastructure, as well as the potential of the school's surrounding environment. This analysis is crucial as a basis for consideration in developing teaching materials to align with the characteristics of the learning context and student needs. Based on the results of initial observations and field studies, science laboratory facilities at the research location school are still relatively limited and inadequate to support practical activities, particularly on ecosystems. The school does not yet have a dedicated, representative science laboratory, and the availability of relevant experimental tools and materials is still very limited. This situation impacts students' opportunities to engage in hands-on investigative activities. As a result, science learning is predominantly conducted in the classroom with a textbook-based approach, thus under-facilitating exploratory and experimental scientific activities.

These limitations imply that ecosystem learning tends to be conceptual and does not provide authentic learning experiences for students. Students do not have adequate opportunities to directly observe the interactions between biotic and abiotic components in real environments, resulting in a less meaningful knowledge construction process. However, the characteristics of ecosystems require a contextual and observation-based approach to foster in-depth student understanding. Therefore, alternative learning environments that accommodate authentic observation and investigation are needed to improve the quality of science learning in elementary schools. The results of this study indicate a significant gap between the demands of science learning oriented toward scientific literacy and practical learning in the field, which is still dominated by conceptual and textbook-based approaches. Limited laboratory facilities and a lack of experimental activities prevent students from gaining adequate scientific experience (Suprapto et al., 2021). This finding aligns with research confirming that low scientific literacy in Indonesia is inextricably linked to the dominance of theoretical learning that inadequately connects concepts to real-world contexts (Bada, 2022; Wang & Kumar, 2026). From the perspective of modern science learning, this situation indicates the suboptimal implementation of the scientific inquiry approach, which should be the foundation for developing scientific literacy (Abdullah et al., 2025). Active student involvement in the process of observation, experimentation, and data interpretation is a key prerequisite for building meaningful conceptual understanding.

Furthermore, the results of this study reinforce the importance of context-based learning as a strategy to bridge this gap (Chanrak & Pimvichai, 2023; Suprapto et al., 2022). Utilizing the environment as a learning resource, including mangrove ecosystems, has been shown to have significant potential in supporting more authentic and contextual learning (Morrison et al., 2021). This is consistent with Suryawati and Osman (2018), who showed that contextual learning significantly improves students' scientific attitudes and science performance. Through direct interaction with environmental phenomena, students not only cognitively understand ecosystem concepts but also develop science process skills such as observing, classifying, and drawing evidence-based conclusions. The findings of this study also indicate that the Tuban Mangrove Center has the potential to act as a natural laboratory, replacing the limitations of formal laboratories in schools. The biodiversity and complexity of ecosystem interactions in the area provide rich learning resources for developing students' scientific literacy holistically (Abubakar et al., 2024; Dian et al., 2024). This aligns with Hernawati et al. (2019), who demonstrated that project-based learning utilizing local potential can significantly improve scientific literacy skills. Furthermore, Suryawati and Osman (2018) confirmed that environment-based learning experiences can strengthen students' scientific thinking and problem-solving skills contextually.

However, this study also revealed that the utilization of local potential, particularly the Tuban Mangrove Center, has not been systematically integrated into learning materials. Teachers still display a high dependence on conventional teaching materials and lack learning designs that comprehensively integrate local potential (Bada, 2022; Muliadi et al., 2017). This situation indicates an urgent need to develop locally based learning designs that are not only relevant to students' environmental context but also aligned with the learning outcomes of the Independent Curriculum. As Ardan (2016) noted, integrating local wisdom into science learning not only improves conceptual understanding but also fosters environmental stewardship and ecological awareness in students. Therefore, the results of this study confirm that strengthening scientific literacy is inseparable from a transformation in learning approaches toward contextual, environmentally-based, and hands-on experience-oriented learning. Developing a learning design based on the Tuban Mangrove Center is a strategic step to optimize local potential as a learning resource, while addressing the challenge of low scientific literacy among elementary school students. Furthermore, this integration contributes to building ecological awareness from an early age, a crucial component of sustainable education in the 21st century.

CONCLUSION

This study reveals that science learning on ecosystems in elementary schools is still dominated by a conceptual and textbook-based approach, thus failing to facilitate authentic scientific learning experiences. Limited laboratory facilities and the unavailability of contextual teaching materials are the main factors contributing to low student engagement in scientific observation and investigation activities. This situation indicates a gap between the curriculum's demands, which emphasize contextual and environment-based learning, and practical learning in the field. On the other hand, the Tuban Mangrove Center has significant potential as a natural laboratory capable of strengthening scientific literacy through learning experiences based on observation, investigation, and contextual problem-solving. However, this potential has not been optimally utilized due to the lack of a systematic learning design integrated with teaching materials. Therefore, this needs analysis emphasizes the urgency of developing a learning design based on local potential that is contextual, structured, and aligned with learning outcomes to improve both scientific literacy and ecological awareness in elementary school students. Based on the research findings, the following recommendations are made. First, it is necessary to develop a science learning design based on the local potential of the Tuban Mangrove Center, integrated into teaching modules, teaching materials, and scientific inquiry-based learning activities. Second, teachers need to be provided with training and mentoring in designing contextual learning that utilizes the environment as a learning resource, thereby reducing reliance on textbooks. Third, systematic collaboration between schools and Mangrove Center management is needed to develop sustainable, environmentally-based learning programs. Fourth, further research is recommended to develop and test the effectiveness of mangrove-based learning designs on improving students' scientific literacy through an experimental or research and development (R&D) approach. Furthermore, more in-depth studies are needed to explore the integration of other local potentials into science learning to strengthen the relevance and meaningfulness of learning in elementary schools.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

CONFLICTING INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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