Journal of Advanced Sciences and Mathematics Education
Volume 6, Issue 1, 130-143
e_ISSN: 2798-2351
DOI: 10.58524/jasme.v6i1.1077

Integrating local wisdom into ipas learning to strengthen students' critical thinking: An analysis of gondolio as a learning resource in elementary schools

Aris Naeni Dwiyanti
Universitas Nahdlatul Ulama
Al Ghazali Cilacap Indonesia

Article Info

Article history:

Received: Jan 03, 2026
Revised: Feb 18, 2026
Accepted: March 08, 2026

Keywords:

Critical Thinking; Gondolio; IPAS Learning; Local Wisdom; Primary Education.

Abstract

Background: Critical thinking is widely recognized as an essential competence in twenty-first century education. Integrating local wisdom into IPAS learning can connect scientific concepts with students' cultural and environmental contexts.
Aims: This study aims to examine how local wisdom-based learning contributes to the development of critical thinking in IPAS learning and to analyze the potential of Gondolio, a traditional bamboo musical instrument from Banyumas, as a learning resource in elementary schools.
Method: This research employed a mixed-method approach combining a systematic literature review and qualitative analysis. The literature review examined studies related to local wisdom and critical thinking in science learning published between 2019 and 2024 using Publish or Perish and VOSviewer. Qualitative data were obtained through interviews with local cultural practitioners and analysis of curriculum documents from the Merdeka Curriculum.
Results: The literature review indicates that integrating local wisdom into science-related learning can support the development of students' critical thinking through contextual learning experiences. The qualitative findings show that Gondolio contains several concepts relevant to IPAS learning, including sound phenomena, plant classification, material changes, and cultural diversity.
Conclusion: Using Gondolio as a learning resource provides contextual learning opportunities that connect scientific concepts with local cultural practices, thereby supporting the development of students' critical thinking in elementary education.

To cite this article: Dwiyanti, A, N., (2025). Integrating Local Wisdom into IPAS Learning to Strengthen Students' Critical Thinking: An Analysis of Gondolio as a Learning Resource in Elementary Schools in Banyumas. *Journal of Advanced Sciences and Mathematics Education*. *6*(1), 130-143.

INTRODUCTION

The rapid advancement of science and technology in the twenty-first century requires educational systems to cultivate higher-order thinking skills among students, particularly critical thinking (Zainil et al., 2023). Learners are not only expected to understand concepts but also to analyze information, evaluate arguments, and respond to various real-life challenges in a thoughtful and reasoned manner (Demir & Namdar, 2021). Nevertheless, classroom practices in many schools still tend to emphasize the delivery of content rather than encouraging students to engage in analytical and reflective thinking. This situation highlights the importance of developing learning approaches that can effectively foster students' critical thinking abilities.

At the elementary school level, the development of critical thinking needs to be supported through meaningful learning experiences that are closely related to students' everyday lives

*** Corresponding author:**
Aris Naeni Dwiyanti, Universitas Nahdlatul Ulama Al Ghazali Cilacap, Indonesia
arisnaeni@unugha.id

(Lombardi et al., 2021). Science learning, including IPAS (Integrated Natural and Social Sciences), is designed to help students understand the relationships between natural phenomena and social life. Through this subject, students are encouraged not only to learn scientific concepts but also to recognize their relevance to human activities and environmental interactions.

The implementation of the Merdeka Curriculum in Indonesia emphasizes contextual and student-centered learning. One approach that supports this principle is the integration of local wisdom into classroom learning (Hanapi et al., 2025). Local wisdom reflects the knowledge, values, and cultural practices that develop within a community and are closely connected to its natural and social environment. When such cultural elements are incorporated into learning activities, scientific concepts can be presented in contexts that are more familiar and meaningful to students.

Learning experiences that connect scientific ideas with local cultural practices provide opportunities for students to observe, question, and interpret phenomena that exist in their own surroundings (Garzón-Díaz, 2021; Kwangmuang et al., 2021). Such contextual learning environments encourage students to participate actively in the learning process and support the development of higher-order thinking skills (Cojorn & Sonsupap, 2024). By linking scientific knowledge with real-world contexts, students may gain deeper conceptual understanding and stronger analytical abilities.

In Banyumas, one example of local wisdom that reflects both cultural traditions and environmental knowledge is Gondolio, a traditional bamboo musical instrument historically associated with agricultural life. Gondolio produces sound through differences in the size and structure of bamboo, which relates to scientific concepts such as sound vibration, plant characteristics, and material properties (Adier et al., 2023; Bosia et al., 2022). Despite its potential as a contextual learning resource, the use of Gondolio in IPAS learning at the elementary school level remains limited. Exploring its educational potential may therefore open new opportunities for integrating local wisdom into science-related learning while supporting the development of students' critical thinking skills.

Critical thinking is widely regarded as an essential component of meaningful learning, particularly in science education (García-Carmona, 2025; van den Berg & du Plessis, 2023). This ability involves analyzing information, evaluating arguments, and drawing logical conclusions when dealing with various problems or phenomena (Zhai et al., 2024). In educational settings, the development of critical thinking enables students to move beyond simple memorization toward deeper understanding and reasoned judgment.

Various instructional approaches have been introduced to encourage the development of critical thinking in science-related subjects (Irwanto, 2023; Tian et al., 2025). Learning strategies that emphasize inquiry, problem solving, and contextual exploration invite students to investigate scientific phenomena actively rather than passively receiving information (Morris, 2025). Through such activities, learners engage in questioning, interpreting evidence, and constructing explanations based on observation and reasoning. Contextual learning has also been recognized as an effective way to connect academic knowledge with students' lived experiences (Fantinelli et al., 2024). When learning activities are linked to situations that students encounter in their daily lives, scientific ideas can become easier to understand and more meaningful (Hiğde & Aktamış, 2022; Ramdani et al., 2021). Such learning environments often enhance students' motivation and engagement while helping them grasp scientific concepts more concretely.

Recent developments in science education have also emphasized the role of ethnoscience, which integrates cultural knowledge and traditional practices into formal learning. Cultural artifacts, traditional technologies, and community practices frequently embody scientific principles that can be explored within educational contexts. When these cultural elements are incorporated into learning activities, students can examine scientific ideas from multiple perspectives while developing analytical thinking skills. Although numerous studies have discussed the integration of local wisdom

into science education, many of these studies still address local wisdom at a conceptual level or treat it as a general contextual element in learning (Sakti et al., 2024). Existing research often highlights the educational value of cultural knowledge and ethnoscience in enriching learning experiences, yet it rarely explains how specific cultural resources can be systematically integrated into classroom instruction. Furthermore, research on local wisdom in science education frequently focuses on traditional environmental knowledge or broad cultural practices. While such studies contribute to understanding the relationship between culture and science, they often overlook the potential of particular cultural artifacts that contain explicit scientific concepts and could function as concrete learning resources.

Within the context of IPAS learning in elementary schools, this gap becomes even more significant. IPAS is designed as an integrative subject that combines perspectives from natural sciences and social sciences. Such an interdisciplinary framework offers considerable potential for incorporating local cultural resources that connect natural phenomena with the social and cultural lives of communities (Swanson et al., 2021; Varghese & Crawford, 2021). However, research that specifically examines how local cultural artifacts can be aligned with IPAS concepts and used to support the development of students' critical thinking remains limited. Gondolio, a bamboo-based traditional musical instrument originating from Banyumas, represents one example of cultural heritage that embodies both scientific and social dimensions. The instrument reflects principles related to sound production, plant characteristics, and material properties while also representing local cultural traditions (Aslan & Karahasanoğlu, 2021). Despite this potential, the educational role of Gondolio as a contextual learning resource in IPAS learning has rarely been explored. This gap indicates the need for studies that investigate how such cultural artifacts can be integrated into science-related learning to enhance students' critical thinking.

The integration of local wisdom into learning becomes increasingly relevant in educational approaches that emphasize contextual and student-centered learning. When scientific concepts are connected to students' cultural environments, learning experiences become more meaningful and easier to understand (Valladares, 2021). Cultural practices that exist within the community can serve as authentic contexts that encourage students to observe phenomena, ask questions, and construct explanations based on real-life experiences. Gondolio provides an interesting context for integrating scientific and social concepts within IPAS learning. As a bamboo musical instrument, it involves several scientific ideas such as sound vibration, plant morphology, and material properties (Deng et al., 2022). At the same time, Gondolio represents the cultural traditions of the Banyumas community. These characteristics make it a potential learning resource that links scientific understanding with cultural experience.

This study aims to examine how local wisdom-based learning contributes to the development of critical thinking in IPAS learning and to analyze the potential of Gondolio as a contextual learning resource in elementary schools in Banyumas. In addition, the study seeks to explore how cultural artifacts that embody both scientific and social dimensions can be integrated into science-related learning to create more meaningful and contextually relevant learning experiences for students.

METHOD

Research Design

This study adopted a mixed-methods design that integrates a systematic literature review with qualitative inquiry. The combination of these approaches was intended to provide a comprehensive understanding of the role of local wisdom in supporting students' critical thinking within IPAS learning while also examining the potential of Gondolio as a contextual learning resource in elementary education. The research was conducted in two main phases. The first phase involved a systematic literature review aimed at identifying scholarly discussions and research trends related

to the integration of local wisdom and its contribution to the development of critical thinking in science-related learning. The second phase employed qualitative exploration to examine how Gondolio, a traditional bamboo musical instrument originating from Banyumas, could be utilized as a contextual learning resource within IPAS instruction in elementary schools.

Participants

The qualitative component of the study involved elementary school teachers who teach IPAS subjects in Banyumas. Participants were selected purposively, as they possess practical experience implementing the Merdeka Curriculum and have familiarity with contextual teaching practices within their classrooms. In addition to teacher participants, several curriculum-related documents were examined to support the analysis. These documents included Capaian Pembelajaran (CP), Alur Tujuan Pembelajaran (ATP), and instructional modules related to IPAS learning. The analysis of these documents helped identify possible connections between Gondolio and the competencies expected in elementary-level IPAS instruction.

Research Procedure

The study followed a sequence of research stages designed to systematically investigate the integration of local wisdom into IPAS learning and its relevance to the development of students' critical thinking skills. The research began with the identification of the research problem and the formulation of guiding research questions. This stage was followed by a systematic literature review aimed at examining prior studies addressing local wisdom integration, science education, and critical thinking development. The selected literature was subsequently analyzed using bibliometric and thematic approaches in order to identify research patterns and major themes within the existing body of knowledge. Following the literature review stage, field exploration was conducted to gather contextual information regarding the educational potential of Gondolio. This stage involved interviews with teachers as well as an analysis of relevant curriculum documents.

The collected information was then examined to explore how Gondolio could function as a contextual learning resource capable of integrating cultural knowledge with scientific understanding within IPAS learning. The final stage involved interpreting the findings and drawing conclusions concerning the educational implications of integrating Gondolio into classroom practice.

The overall research procedure followed in this study is illustrated in Figure 1.

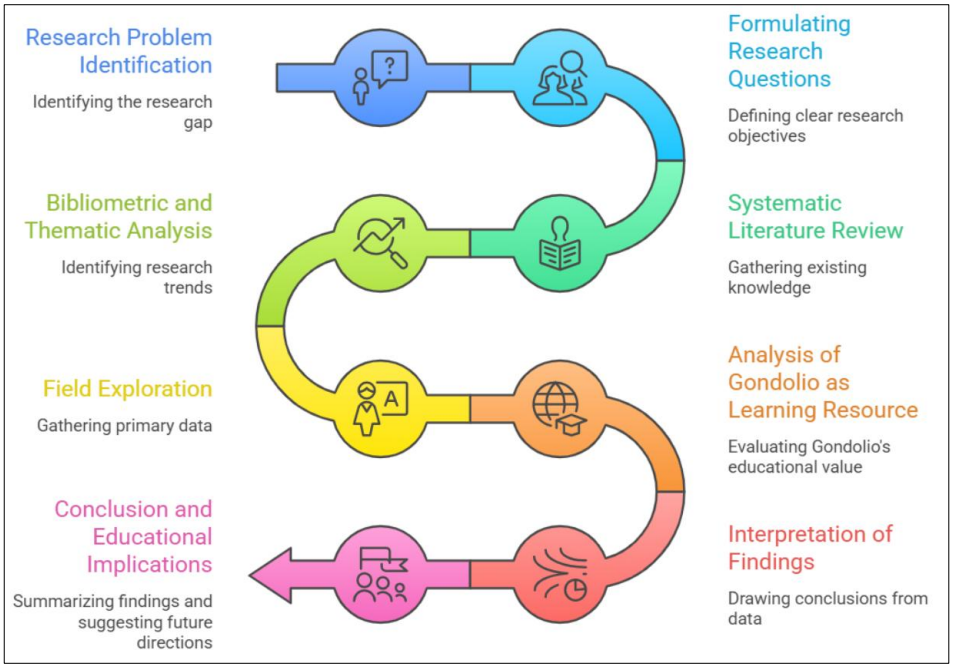

Figure 1. Flowchart of the Research Procedure

Instruments

Several instruments were employed to support data collection and analysis during both phases of the research. These instruments were designed to capture relevant information regarding literature trends, teacher perspectives, and curriculum alignment.

Table 1. Presents the instruments used in the study.

Instrument	Data Collected	Purpose
Literature search strategy	Scientific publications	Identifying relevant studies on local wisdom, science learning, and critical thinking
Semi-structured interview guide	Teacher perspectives	Exploring teachers' views on the integration of Gondolio into IPAS learning
Document analysis sheet	Curriculum documents (CP, ATP, teaching modules)	Examining the relationship between Gondolio and IPAS learning objectives

Data Sources

The study utilized both primary and secondary data sources. Secondary data consisted of scholarly publications related to local wisdom and science education, while primary data were obtained through teacher interviews and curriculum document analysis.
A summary of the data sources used in this study is presented in Table 2.

Table 2. Data Sources Used in the Study

Data Source	Type of Data	Purpose
Scientific articles	Secondary data	Identifying research trends related to local wisdom and critical thinking
Teacher interviews	Primary data	Understanding teachers' perspectives on contextual learning practices
Curriculum documents (CP, ATP)	Documentary data	Examining how Gondolio aligns with IPAS learning content

Literature Selection Criteria

To ensure that the literature review focused on relevant and recent studies, a set of inclusion and exclusion criteria was applied during the article selection process.
The criteria used in the selection process are summarized in Table 3.

Table 3. Inclusion and Exclusion Criteria for Literature Selection

Criteria	Inclusion	Exclusion
Publication year	2019–2024	Publications prior to 2019
Document type	Peer-reviewed journal articles	Books, reports, theses
Research focus	Local wisdom, science learning, critical thinking	Topics unrelated to the study
Language	English or Indonesian	Other languages

Data Analysis

Data analysis was conducted in accordance with the two phases of the study. During the literature review phase, retrieved publications were examined using bibliometric and thematic analysis techniques. The Publish or Perish software was employed to identify relevant publications from the Google Scholar database, while VOSviewer was used to visualize keyword relationships and research trends related to local wisdom and critical thinking in science education. For the qualitative phase, the collected interview data and curriculum documents were analyzed using a descriptive qualitative approach. The analysis focused on identifying themes related to the integration of Gondolio within IPAS learning and examining how this cultural artifact could serve as a contextual learning resource that supports the development of students' critical thinking.

RESULTS AND DISCUSSION

Results

Results of the Systematic Literature Review

This study began with a systematic literature review to identify research trends concerning the integration of local wisdom in science-related learning and its potential contribution to the development of students' critical thinking skills. The review focused on publications discussing the relationship between cultural knowledge, science learning, and contextual educational approaches.

The selected articles were analyzed using VOSviewer to examine the relationships among keywords appearing in relevant publications. The analysis produced a visualization showing clusters of interconnected concepts frequently discussed in previous studies.

The results of the keyword mapping reveal several clusters representing major themes in the literature. The red cluster mainly represents themes related to science learning, instructional media, and educational strategies. Meanwhile, the green cluster reflects discussions related to local wisdom, including language, cultural traditions, ethnoscience, and community knowledge systems.

The close relationship between these clusters indicates that local wisdom has increasingly been integrated into science education. Several studies also emphasize learning outcomes associated with this integration, including improvements in scientific literacy, learning engagement, and critical thinking skills. These findings suggest that incorporating cultural contexts into science learning can enhance meaningful learning experiences for students.

The visualization of keyword relationships obtained from the bibliometric analysis is presented in Figure 5.

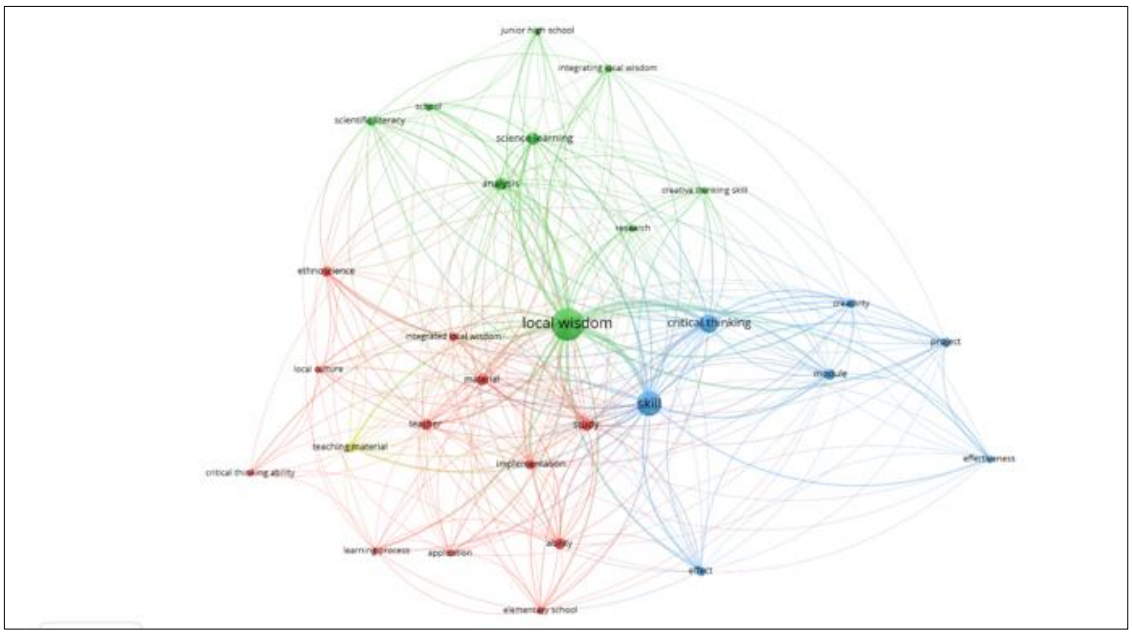

Figure 2. The Result of Mapping Correlation in the Relevant Articles' Keywords

To further understand how local wisdom had been integrated into science learning contexts, a summary of relevant studies identified through the systematic literature review in Table 1.

Table 1. Summary of Studies on Local Wisdom Integration in Science Learning

No	Focus of Study	Local Wisdom Context	Learning Outcome
1	Biodiversity learning	Banjar language integration	Improved student thinking skills
2	Environmental science	Belitung Geopark	Contextual understanding of geological concepts
3	Physics learning	Traditional brown sugar production	Understanding heat and temperature concepts

No	Focus of Study	Local Wisdom Context	Learning Outcome
4	Ethnoscience-based learning	Community cultural practices	Increased student engagement
5	Local wisdom-based science module	Traditional knowledge systems	Development of scientific literacy
6	Culture-based science education	Local environmental practices	Strengthened contextual learning
7	Science learning with local media	Traditional technology	Enhanced conceptual understanding
8	Ethnoscience integration	Indigenous knowledge	Improved science learning relevance
9	Cultural resource-based learning	Community traditions	Increased learning motivation
10	Local wisdom in science education	Traditional practices	Support for critical thinking development

The findings from these studies indicate that local wisdom can provide meaningful contexts for science learning while also supporting the development of higher-order thinking skills.

Integration of Gondolio in IPAS Learning

The second stage of the study focused on examining the potential integration of Gondolio, a traditional bamboo musical instrument originating from Banyumas, into elementary school IPAS learning. This analysis was based on interview results and curriculum document analysis. Gondolio is a traditional musical instrument historically used by local communities as a form of entertainment, particularly after agricultural activities. The instrument resembles an angklung and uses a slendro pentatonic scale consisting of four tones. Because the instrument contains only four tone bars, songs played using Gondolio typically follow a four-tone melodic structure.

Examples of songs commonly performed using Gondolio include Gondolio, Kulu-Kulu, Bendrong Kulon, Jaran Kepang, Jemuah Wage, and Tole-Tole. The instrument is typically played by a single performer who simultaneously produces the melody while humming the tune. In this context, Gondolio functions mainly as a melodic instrument, although harmonic elements may appear depending on how the melody is performed. Beyond its musical function, Gondolio represents an important cultural heritage within the Banyumas community. However, the instrument is becoming increasingly rare and is mostly recognized by older generations. Many elementary school students and even teachers are unfamiliar with this traditional instrument. Therefore, integrating Gondolio into learning activities may contribute not only to science education but also to the preservation of local cultural heritage.

Scientific Concepts Embedded in Gondolio

The analysis shows that Gondolio contains several scientific concepts that can be explored within IPAS learning. These concepts originate from different scientific disciplines and allow students to connect cultural practices with scientific understanding. From a biological perspective, Gondolio is made from bamboo, particularly Gigantochloa atroviolacea, commonly known as black bamboo. This bamboo species grows in lowland areas up to approximately 650 meters above sea level and is characterized by its dark-colored stems. From a physics perspective, Gondolio can be used to explain concepts related to sound vibration and sound frequency. Differences in bamboo size and structure influence the sound produced by the instrument. From a chemistry perspective, the preservation process of bamboo materials introduces students to concepts related to material properties and chemical treatment processes. These scientific concepts embedded in Gondolio are summarized in Table 2.

Table 2. Scientific Concepts Embedded in Gondolio for IPAS Learning

Scientific Domain	Concept	Learning Context
Biology	Bamboo species (Gigantochloa atroviolacea)	Plant morphology and biodiversity
Physics	Sound vibration	Sound production in musical instruments
Physics	Sound frequency	Differences in bamboo size and pitch
Chemistry	Material preservation	Bamboo treatment process
Social Science	Cultural heritage	Local traditions in Banyumas
Social Science	Community practices	Traditional music performance

The presence of these interdisciplinary concepts indicates that Gondolio can serve as a contextual learning resource that integrates scientific knowledge with cultural understanding.

Alignment of Gondolio with IPAS Learning Objectives

The findings were also analyzed in relation to the IPAS learning objectives within the Merdeka Curriculum. IPAS learning integrates natural science and social science perspectives to help students understand relationships between scientific knowledge and social contexts.

Through this integrative framework, Gondolio can be connected with several learning topics within IPAS, including biodiversity, sound phenomena, plant morphology, and cultural diversity. The alignment between Gondolio and IPAS learning objectives is summarized in Table 3.

Table 3. Alignment of Gondolio with IPAS Learning Objectives

IPAS Topic	Gondolio Context	Learning Activity
Biodiversity	Bamboo plants	Observing bamboo characteristics
Sound	Musical instrument vibration	Measuring sound frequency
Material properties	Bamboo structure	Exploring material strength
Cultural diversity	Traditional music	Understanding local heritage

These learning activities allow students to explore scientific concepts while simultaneously understanding the cultural context in which these concepts exist.

Conceptual Integration of Gondolio in IPAS Learning

The results from literature analysis, interviews, and curriculum document analysis indicate that Gondolio can be integrated into IPAS learning as a contextual resource that connects cultural knowledge with scientific concepts. The integration process begins with identifying Gondolio as a cultural artifact that contains both scientific and social dimensions. Students can explore the instrument through its production process, raw materials, and cultural functions within the community.

The production process involves simple tools such as saws, drills, and hammers, which can serve as meaningful learning media for introducing students to fundamental scientific concepts. Through these tools, students can explore the principles of simple machines, particularly lever mechanisms, by observing how force, motion, and mechanical advantage operate in real activities. When students analyze how these tools function in the Gondolio production process, they are not only learning about traditional craftsmanship but also connecting practical experiences with scientific explanations. This contextual approach allows learners to understand scientific concepts in a more concrete and relatable way, thereby supporting deeper conceptual comprehension within IPAS learning.

In addition to the technological aspects of the production process, Gondolio performances also represent rich cultural traditions that integrate music, dance, and collective community participation. These cultural elements provide opportunities to contextualize science learning within students' sociocultural environments. Based on the analysis of both the production process and the cultural performance, a conceptual framework was developed to describe how Gondolio can be

integrated into IPAS learning. The framework illustrates the relationship between cultural knowledge, scientific concepts, and classroom learning activities, showing how these components interact to foster students' critical thinking skills. The conceptual framework of Gondolio integration in IPAS learning is presented in Figure 8.

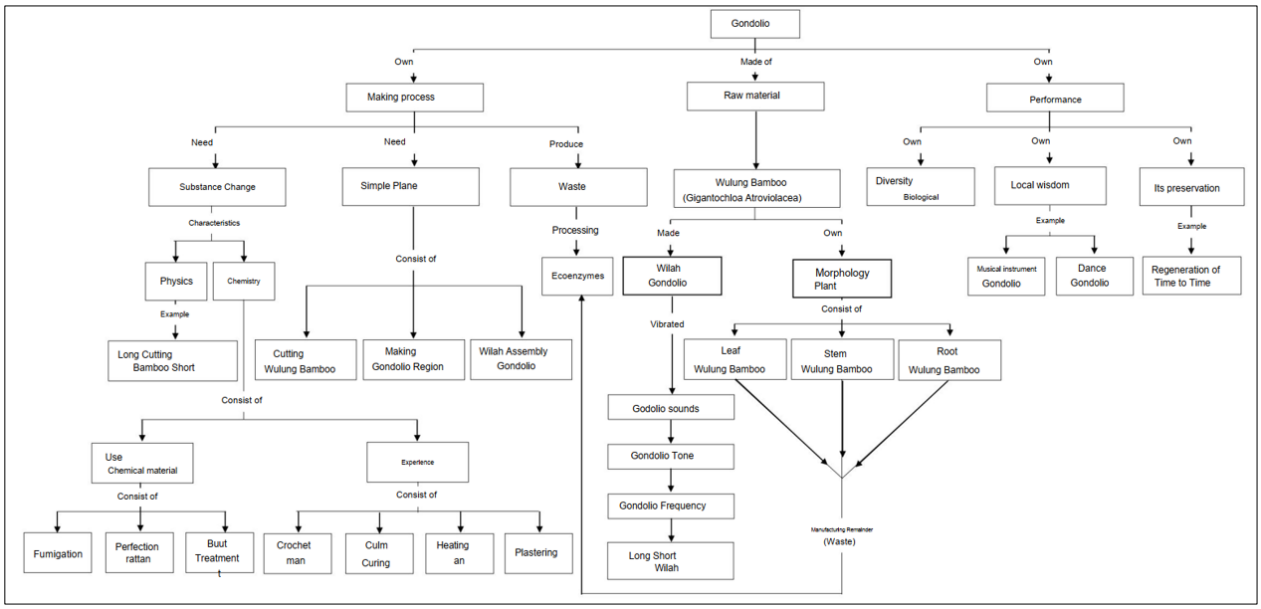

Figure 3. Concept Map of IPAS Learning Integrated with Gondolio Local Wisdom

Discussion

The results of this study demonstrate that local wisdom can play a meaningful role in enriching science-related learning in elementary schools. The findings obtained from the systematic literature review indicate that the integration of cultural knowledge into science education has increasingly been explored as a way to provide contextual learning experiences for students (Ogegbo & Ramnarain, 2024). In many cases, local cultural practices are closely related to natural phenomena, making them suitable as learning resources that connect scientific concepts with students' everyday environments (Ardoin & Heimlich, 2021). When learning is presented through contexts that are familiar to students, the process of understanding scientific ideas becomes more accessible and meaningful.

The literature analysis conducted in this study also shows that the integration of local wisdom is frequently associated with the development of higher-order thinking skills. Contextual learning environments allow students to explore real phenomena, ask questions, and interpret information based on their observations. These learning processes naturally involve analytical thinking, reasoning, and interpretation, which are essential components of critical thinking (Loyens et al., 2023). Therefore, incorporating cultural contexts into science learning may provide opportunities for students to engage more actively in the learning process.

Within the context of IPAS learning in elementary schools, the integration of local cultural resources offers considerable potential. IPAS is designed as an interdisciplinary subject that combines perspectives from natural sciences and social sciences. Through this structure, students are encouraged to understand not only scientific concepts but also their relationships with social and cultural realities. This integrative nature of IPAS creates opportunities for teachers to utilize cultural elements from the surrounding environment as learning resources that support both conceptual understanding and cultural awareness (Garzón-Díaz, 2021).

The findings of this study show that Gondolio, a traditional bamboo musical instrument from Banyumas, contains several scientific concepts that can be explored within the context of IPAS learning. The use of bamboo as the main material for the instrument allows students to examine

biological concepts related to plant morphology and biodiversity. At the same time, the sound produced by Gondolio introduces physical concepts such as vibration and sound frequency. In addition, the process of preserving bamboo materials reflects basic chemical principles related to material properties (Mohan et al., 2022). These interdisciplinary elements illustrate how traditional cultural artifacts may contain various forms of scientific knowledge embedded within local practices.

Beyond its scientific relevance, Gondolio also represents an important cultural heritage of the Banyumas community. Traditional musical instruments such as Gondolio reflect local identity and collective cultural memory that have been maintained across generations. However, the results of this study also reveal that knowledge about Gondolio among younger generations has gradually decreased. Many elementary school students are unfamiliar with this instrument, and even some teachers have limited knowledge about its cultural significance (Sarwanto et al., 2021). In this situation, integrating Gondolio into educational contexts may serve a dual purpose: supporting science learning while also contributing to the preservation of local cultural heritage.

Learning activities that involve the exploration of Gondolio can encourage students to develop analytical thinking skills (Mangion et al., 2025). For example, when students investigate how variations in bamboo size influence sound production, they are required to observe patterns, compare results, and interpret relationships between physical properties and sound frequency. These processes require students to engage in reasoning and explanation, which are important aspects of critical thinking (Gunawardena & Wilson, 2021). Through such explorations, students are not only learning scientific concepts but also developing the ability to analyze and interpret phenomena more systematically.

Furthermore, the integration of local wisdom into learning activities is consistent with the principles emphasized in the Merdeka Curriculum, which promotes contextual and student-centered learning (Ramli et al., 2025). By incorporating cultural resources from the surrounding environment, teachers can create learning experiences that are more relevant to students' lives. Such learning environments may increase students' motivation and curiosity, while also encouraging them to explore scientific ideas through real-world situations (Do et al., 2023).

Overall, the findings of this study suggest that integrating local wisdom into IPAS learning can provide meaningful opportunities to strengthen students' critical thinking skills. Cultural artifacts such as Gondolio offer authentic contexts that allow students to connect scientific concepts with cultural practices within their community. Through this approach, learning becomes not only a process of acquiring knowledge but also a way for students to understand the relationships between science, culture, and their surrounding environment (Sakti et al., 2024).

Implications

The results of this study indicate that integrating local wisdom into IPAS learning can contribute to creating learning experiences that are more contextual and meaningful for elementary school students. When scientific concepts are connected with cultural practices that exist in students' surrounding environments, abstract ideas become easier to understand and more relevant to everyday life. The analysis of Gondolio demonstrates that traditional cultural artifacts may contain various scientific concepts related to biology, physics, and material properties, which can be explored as part of interdisciplinary learning activities. Through such learning contexts, students are encouraged to observe phenomena, interpret relationships between concepts, and construct explanations based on real situations. In addition to supporting the development of critical thinking skills, the use of cultural elements in learning may also strengthen students' awareness of local cultural heritage and help maintain the relevance of traditional knowledge within modern educational practices.

Limitations

This study has several limitations that should be considered when interpreting the findings. The research focuses specifically on Gondolio as a cultural artifact originating from Banyumas, which means the results mainly reflect the characteristics of this particular cultural context. As a consequence, the findings cannot automatically represent the potential of other forms of local wisdom that may exist in different regions. In addition, the study relies on literature analysis, interviews, and curriculum document analysis to examine the potential use of Gondolio as a learning resource. The research therefore emphasizes conceptual analysis rather than direct classroom implementation. Because no experimental or classroom-based intervention was conducted, the study does not measure the direct influence of Gondolio-based learning activities on students' critical thinking performance, but instead provides an analytical exploration of its potential role within IPAS learning.

Suggestions

Future research may expand the findings of this study by examining how local wisdom-based learning can be implemented directly in classroom settings. Experimental or quasi-experimental approaches could be used to investigate how integrating cultural artifacts such as Gondolio influences students' critical thinking skills, learning engagement, and conceptual understanding during actual learning activities. Further studies may also explore other forms of local cultural knowledge that contain scientific principles embedded within traditional practices in different regions. Investigating a wider range of cultural contexts may contribute to the development of learning models that combine scientific knowledge with local cultural resources. In addition, collaboration between educators, cultural practitioners, and local communities may support the development of learning materials that preserve cultural authenticity while providing meaningful and contextually relevant learning experiences for students.

CONCLUSION

This study explored how local wisdom can be incorporated into IPAS learning by examining the educational potential of Gondolio, a traditional bamboo musical instrument originating from Banyumas. The findings indicate that cultural knowledge embedded in traditional practices can provide meaningful contexts for learning scientific concepts. The analysis shows that Gondolio reflects several scientific principles related to plant characteristics, sound production, and material properties, allowing it to be used as a learning resource that connects natural science concepts with cultural experiences familiar to students. Through such contextual learning situations, students have opportunities to observe phenomena, interpret relationships between concepts, and develop analytical reasoning. In addition to supporting the development of critical thinking skills, the use of local cultural elements in learning can also strengthen students' awareness of the cultural heritage that exists within their community. Integrating local wisdom into IPAS learning therefore offers a constructive pathway for creating learning experiences that are both scientifically meaningful and culturally relevant for elementary school students.

AKNOWLEDGMENT

The authors would like to express their sincere appreciation to all individuals and institutions who supported the completion of this study. Special gratitude is extended to the participants who were willing to share their knowledge and experiences regarding the cultural practice of Gondolio in Banyumas. The authors also thank the educational practitioners and local community members who provided valuable insights that contributed to the understanding of Gondolio as a potential learning

resource in IPAS education. Their cooperation and support played an important role in the completion of this research.

REFERENCES

Adier, M. F. V., Sevilla, M. E. P., Valerio, D. N. R., & Ongpeng, J. M. C. (2023). Bamboo as Sustainable Building Materials: A Systematic Review of Properties, Treatment Methods, and Standards. *Buildings*, *13*(10), 2449. https://doi.org/10.3390/buildings13102449

Ardoin, N. M., & Heimlich, J. E. (2021). Environmental learning in everyday life: Foundations of meaning and a context for change. *Environmental Education Research*, *27*(12), 1681–1699. https://doi.org/10.1080/13504622.2021.1992354

Aslan, U., & Karahasanoğlu, S. (2021). Sound Ethnobiology of Musical Instruments: A Sound View of Nature in Manufacturing Kemençe. *Musicologist*, *5*(2), 240–263. https://doi.org/10.33906/musicologist.988011

Bosia, F., Poggetto, V. F. D., Gliozzi, A. S., Greco, G., Lott, M., Miniaci, M., Ongaro, F., Onorato, M., Seyyedizadeh, S. F., Tortello, M., & Pugno, N. M. (2022). Optimized structures for vibration attenuation and sound control in nature: A review. *Matter*, *5*(10), 3311–3340. https://doi.org/10.1016/j.matt.2022.07.023

Cojorn, K., & Sonsupap, K. (2024). A collaborative professional development and its impact on teachers' ability to foster higher order thinking. *Journal of Education and Learning (EduLearn)*, *18*(2), 561–569. https://doi.org/10.11591/edulearn.v18i2.21182

Demir, A., & Namdar, B. (2021). The Effect of Modeling Activities on Grade 5 Students' Informal Reasoning About a Real-Life Issue. *Research in Science Education*, *51*(1), 429–442. https://doi.org/10.1007/s11165-019-09896-8

Deng, L., Chen, F., Ren, X., & Jiang, Z. (2022). An environmentally friendly and efficient method to improve the acoustic vibration performance of bamboo for musical instruments: Nitrogen-protected heat treatment. *Industrial Crops and Products*, *188*, 115554. https://doi.org/10.1016/j.indcrop.2022.115554

Do, H.-N., Do, B. N., & Nguyen, M. H. (2023). 3How do constructivism learning environments generate better motivation and learning strategies? The Design Science Approach. *Heliyon*, *9*(12). https://doi.org/10.1016/j.heliyon.2023.e22862

Fantinelli, S., Cortini, M., Di Fiore, T., Iervese, S., & Galanti, T. (2024). Bridging the Gap between Theoretical Learning and Practical Application: A Qualitative Study in the Italian Educational Context. *Education Sciences*, *14*(2), 198. https://doi.org/10.3390/educsci14020198

García-Carmona, A. (2025). Scientific Thinking and Critical Thinking in Science Education. *Science & Education*, *34*(1), 227–245. https://doi.org/10.1007/s11191-023-00460-5

Garzón-Díaz, E. (2021). From cultural awareness to scientific citizenship: Implementing content and language integrated learning projects to connect environmental science and English in a state school in Colombia. *International Journal of Bilingual Education and Bilingualism*, *24*(2), 242–259. https://doi.org/10.1080/13670050.2018.1456512

Gunawardena, M., & Wilson, K. (2021). Scaffolding students' critical thinking: A process not an end game. *Thinking Skills and Creativity*, *41*, 100848. https://doi.org/10.1016/j.tsc.2021.100848

Hanapi, Pageh, I. M., Mudana, I. W., & Margi, I. K. (2025). Sustaining the Integration of Local Wisdom into School Life: A Case Study and Bibliometric Approach. *International Journal of Sustainable Development & Planning*, *20*(11), 4903. https://doi.org/10.18280/ijsdp.201129

Hiğde, E., & Aktamış, H. (2022). The effects of STEM activities on students' STEM career interests, motivation, science process skills, science achievement and views. *Thinking Skills and Creativity*, *43*, 101000. https://doi.org/10.1016/j.tsc.2022.101000

Irwanto, I. (2023). Improving Preservice Chemistry Teachers' Critical Thinking and Science Process Skills Using Research-Oriented Collaborative Inquiry Learning. *Journal of Technology and Science Education*, *13*(1), 23–35.

Kwangmuang, P., Jarutkamolpong, S., Sangboonraung, W., & Daungtod, S. (2021). The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools. *Heliyon*, *7*(6). https://doi.org/10.1016/j.heliyon.2021.e07309

Lombardi, L., Mednick, F. J., De Backer, F., & Lombaerts, K. (2021). Fostering Critical Thinking across the Primary School's Curriculum in the European Schools System. *Education Sciences*, *11*(9), 505. https://doi.org/10.3390/educsci11090505

Loyens, S. M. M., van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating Higher-Order, Critical, and Critical-Analytic Thinking in Problem- and Project-Based Learning Environments: A Systematic Review. *Educational Psychology Review*, *35*(2), 39. https://doi.org/10.1007/s10648-023-09757-x

Mangion, M., Valquaresma, A., & Glaveanu, V. P. (2025). Exploring the impact of possibility thinking training on educators' creative self-perceptions: A mixed methods action research study in Maltese schools. *Methods in Psychology*, *13*, 100198. https://doi.org/10.1016/j.metip.2025.100198

Mohan, N., Dash, S. P., Mary Boby, N., & Shetty, D. (2022). Study of bamboo as a building material – Construction & preservation techniques and its sustainability. *Materials Today: Proceedings, Sustainable Materials and Practices for Built Environment*, *60*, 100–114. https://doi.org/10.1016/j.matpr.2021.12.263

Morris, D. L. (2025). Rethinking Science Education Practices: Shifting from Investigation-Centric to Comprehensive Inquiry-Based Instruction. *Education Sciences*, *15*(1), 73. https://doi.org/10.3390/educsci15010073

Ogegbo, A. A., & Ramnarain, U. (2024). A Systematic Review of Pedagogical Practices for Integrating Indigenous Knowledge Systems in Science Teaching. *African Journal of Research in Mathematics, Science and Technology Education*, *28*(3), 343–361. https://doi.org/10.1080/18117295.2024.2374133

Ramdani, A., Jufri, A. W., Gunawan, G., Fahrurrozi, M., & Yustiqvar, M. (2021). Analysis of Students' Critical Thinking Skills in terms of Gender Using Science Teaching Materials Based on The 5E Learning Cycle Integrated with Local Wisdom. *Jurnal Pendidikan IPA Indonesia*, *10*(2), 187–199. https://doi.org/10.15294/jpii.v10i2.29956

Ramli, R., Razali, R., Gadeng, A. N., Diana, N., & Hariadi, J. (2025). Integrating Local Knowledge into Higher Education: A Qualitative Study of Curriculum Innovation in Aceh, Indonesia. *Education Sciences*, *15*(9), 1214. https://doi.org/10.3390/educsci15091214

Sakti, S. A., Endraswara, S., & Rohman, A. (2024a). Revitalizing local wisdom within character education through ethnopedagogy apporach: A case study on a preschool in Yogyakarta. *Heliyon*, *10*(10). https://doi.org/10.1016/j.heliyon.2024.e31370

Sakti, S. A., Endraswara, S., & Rohman, A. (2024b). Revitalizing local wisdom within character education through ethnopedagogy apporach: A case study on a preschool in Yogyakarta. *Heliyon*, *10*(10). https://doi.org/10.1016/j.heliyon.2024.e31370

Sarwanto, Fajari, L. E. W., & Chumdari. (2021). CRITICAL THINKING SKILLS AND THEIR IMPACTS ON ELEMENTARY SCHOOL STUDENTS. *Malaysian Journal of Learning and Instruction*, *18*(2), 161–187. https://doi.org/10.32890/mjli2021.18.2.6

Swanson, H. A., Svenning, J.-C., Saxena, A., Muscarella, R., Franklin, J., Garbelotto, M., Mathews, A. S., Saito, O., Schnitzler, A. E., Serra-Diaz, J. M., & Tsing, A. L. (2021). History as grounds for interdisciplinarity: Promoting sustainable woodlands via an integrative ecological and socio-cultural perspective. *One Earth*, *4*(2), 226–237. https://doi.org/10.1016/j.oneear.2021.01.006

Tian, Y., Cui, W., Deng, D., Yi, X., Yang, Y., Zhang, H., & Wu, Y. (2025). ChartGPT: Leveraging LLMs to Generate Charts From Abstract Natural Language. *IEEE Transactions on Visualization and Computer Graphics*, *31*(3), 1731–1745. https://doi.org/10.1109/TVCG.2024.3368621

Valladares, L. (2021). Scientific Literacy and Social Transformation. *Science & Education*, *30*(3), 557–587. https://doi.org/10.1007/s11191-021-00205-2

van den Berg, G., & du Plessis, E. (2023). ChatGPT and Generative AI: Possibilities for Its Contribution to Lesson Planning, Critical Thinking and Openness in Teacher Education. *Education Sciences*, *13*(10), 998. https://doi.org/10.3390/educsci13100998

Varvghese, J., & Crawford, S. S. (2021). A cultural framework for Indigenous, Local, and Science knowledge systems in ecology and natural resource management. *Ecological Monographs*, *91*(1), e01431. https://doi.org/10.1002/ecm.1431

Zainil, M., Kenedi, A. K., Rahmatina, Indrawati, T., & Handrianto, C. (2023). The Influence of a STEM-Based Digital Classroom Learning Model and High-Order Thinking Skills on the 21st-Century Skills of Elementary School Students in Indonesia. *Journal of Education and E-Learning Research*, *10*(1), 29–35.

Zhai, C., Wibowo, S., & Li, L. D. (2024). The effects of over-reliance on AI dialogue systems on students' cognitive abilities: A systematic review. *Smart Learning Environments*, *11*(1), 28. https://doi.org/10.1186/s40561-024-00316-7