

Mapping Indonesian Local Wisdom in Postgraduate Biology Education Theses to Enhance Higher-Order Thinking Skills

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ABSTRACT

Indonesia, known as a megabiodiversity country, has a wealth of local wisdom that has not been fully utilized systematically in advanced science learning. This study aims to explore, map, and assess the potential for integrating local wisdom into the higher education curriculum as an innovative strategy to improve Higher-Order Thinking Skills (HOTS) thinking skills. Using descriptive qualitative methods through exploration and analysis techniques on 10 student theses. Document selection was based on the criteria of theme relevance, depth of integration of science concepts, and relevance to the local context. Data were analyzed using thematic analysis techniques to identify the forms, characteristics, and patterns of local wisdom integration in learning. The results of the analysis show eight main types of local wisdom integrated in learning, such as the use of medicinal plants and ecosystem management. This integration is realized through learning activities that encourage the analysis of contextual phenomena, evaluation of local practices, and the development of science-based solutions. These findings indicate that the integration of local wisdom not only enriches academic content substantially but also significantly stimulates HOTS, which include Critical Thinking, Creative Thinking, Scientific Reasoning, Ethnoconservation, Scientific Attitude and Science Literacy, Bioentrepreneurship, and Problem Solving. Practically, this research provides an important contribution to the development of an adaptive and relevant higher education curriculum model in facing the challenges of globalization by strengthening scientific literacy based on local culture.

Keywords: Local wisdom, teaching materials, HOTS

INTRODUCTION

Local wisdom is a system of knowledge that develops in society and is passed down between generations through interaction with the environment, including values, practices and beliefs that are adaptive to ecological and social conditions (Erman & Wakhidah, 2024; Onyancha, 2024). Indonesia, as a mega-biodiverse country, boasts exceptionally high biodiversity and natural resources. This wealth of local wisdom plays a vital role in natural resource management, embodying principles of sustainability that have been proven in the practices of local communities (Sudibyoy et al., 2021; Wahyudi, 2020). The use of local wisdom has the potential to become a contextual learning resource that effectively connects scientific concepts with the realities of everyday life (Annur et al., 2024; Cirkony et al., 2023; Imaduddin et al., 2020; Suprpto et al., 2021).

The integration of local wisdom into education globally is a crucial focus as part of efforts to improve the quality and relevance of learning. This step aligns with the Sustainable Development Goals (SDG 4) on inclusive and quality education (Arjaya et al., 2024; Chotibuddin et al., 2025). This approach has been proven to create more contextual, meaningful, and culturally relevant learning experiences by linking scientific concepts to students'

real experiences (Greenall & Bailey, 2022; Mustafaoglu et al., 2022; Parmin & Trisnowati, 2024; Rosyidah et al., 2025).

The importance of this contextual approach is in line with the demands of education in the 21st century which requires mastery of Higher-Order Thinking Skills or HOTS competencies (Adams, 2021; Lavi et al., 2021; Muttaqin, 2023). In an effort to respond to these global challenges, educational institutions are now prioritizing the development of instructional strategies for students and prospective teachers to equip them with specific skills that are parameters for a nation's progress (Hujjatusnaini et al., 2022). HOTS achievement can be optimized through material studies that are not only theoretical but also contextual and challenge students' analytical skills through real-world phenomena. Mastery of these skills is crucial because it involves applying thinking processes in complex situations, where students require encouragement and active involvement to systematically solve complex problems (Zulfiani et al., 2020).

Despite its crucial role in enriching the learning experience and strengthening students' cultural identity, the integration of local wisdom is often neglected due to an excessive focus on academic achievement. (Mahrinasari et al., 2024; Parmiti et al., 2021; Sakti et al., 2024). Efforts to integrate local wisdom into learning in Indonesia have been implemented at various levels of education, both through the curriculum and the use of culture-based media. Local wisdom-based learning also supports the development of higher-order thinking skills through inquiry activities and problem-solving based on local phenomena (Martawijaya et al., 2023; Noviana et al., 2023; Yuliarti et al., 2023). Biology learning that integrates local wisdom provides opportunities for students to examine environmental problems contextually and develop solutions based on local cultural values and practices (Papilaya & J. Tuapattinaya, 2022). Most research so far has focused on implementation at the school level or on specific aspects such as ethnoscience and specific learning outcomes (Annur et al., 2024; Misbah et al., 2024; Muyassaroh et al., 2025). Ethnoscience-based learning can improve students' critical thinking skills through the integration of local traditions into science learning materials (Atmojo et al., 2025; Jannah et al., 2022; Muliadi et al., 2025; Parmin & Fibriana, 2020).

Studies that comprehensively map the use of local wisdom as a learning resource in the context of higher education, particularly in the development of teaching materials by students, are still very limited. Research that systematically examines the integration of local wisdom within a structured learning framework for the development of higher-order thinking skills is also scarce. This study aims to describe the forms and patterns of local wisdom utilization by Master of Biology Education students as a learning resource in developing teaching materials. The main focus of this study is directed at the potential of this integration to support the development of students' higher-order thinking skills through systematic mapping.

METHODS

This study uses a qualitative approach with a descriptive analysis method through the analysis map technique to describe the relationship between the applied teaching materials and the thinking skills acquired by students (Lazarsfeld, 1955). The main focus of the research is directed at exploring the thesis documents developed by Master of Biology Education students at Surabaya State University which integrate local wisdom and higher-order thinking skills (HOTS).

Participants and Data Sources

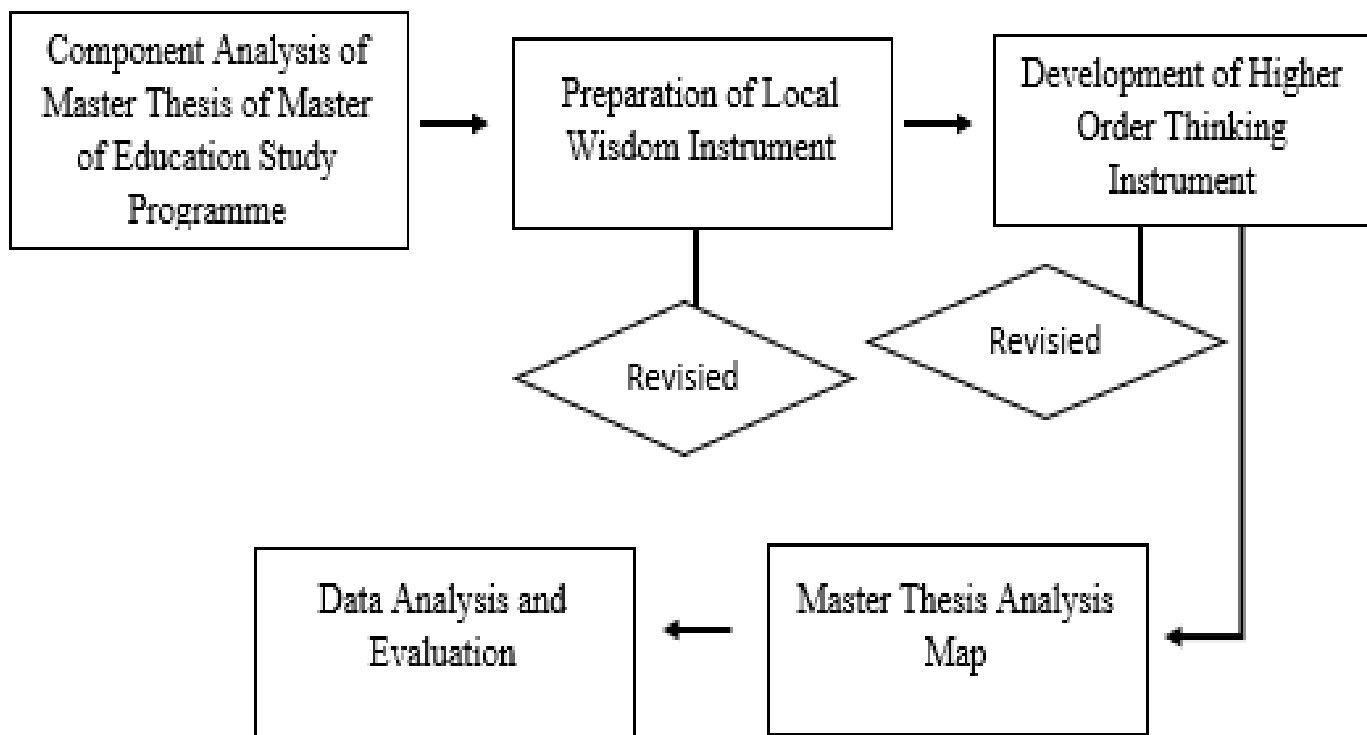
The target of this research is ten (10) master's student theses that have undergone a trial phase in schools. The selection of documents was based on the presence of local wisdom-based teaching materials designed to train complex cognitive abilities. The data collected includes the types of local wisdom integrated and the profile of higher-order thinking skills achieved in the research.

Research Procedures

The research was conducted in five systematic stages. The first stage began with an initial analysis of the thesis to identify local wisdom components. The next stage focused on developing and validating research instruments to input local wisdom data and HOTS parameters. The fourth stage involved implementing an analysis map of

the entire thesis based on the validated instruments. The final stage included comprehensive data analysis and data consistency verification (Figure 1).

Figure 1. Research procedure



Data Collection and Analysis

A special evaluation instrument was developed by the research team to assess the implementation of local wisdom-based teaching materials and their impact on students' cognitive abilities (Merriam, 2009). Analysis maps are used to describe the structural relationship between culture-based materials and HOTS results according to data organization techniques Miles & Huberman (1994). Data analysis was conducted descriptively and qualitatively to gain in-depth insight into the effectiveness of cultural integration in developing critical and creative skills (Sugiyono, 2017). All evaluation results are presented in the form of a systematic table to provide a comprehensive picture of the relationship patterns between variables (Lazarsfeld, 1955).

RESULTS

Analysis of Local Wisdom Integration in Student Theses

Ten theses by Master of Biology Education students from Surabaya State University were analyzed to evaluate the application of local wisdom as teaching materials to develop higher-order thinking skills (HOTS). This integration encompassed various regional contexts, dominated by Java, Madura, and Sumatra. Table 1 summarizes the distribution of local wisdom, the learning models developed, and the types of thinking skills targeted.

Table 1. Results of Analysis of 10 Student Theses

No.	Island and Type of Local Wisdom	Potential Teaching Materials and Learning Models developed	Potential Higher Order Thinking Skills that are trained
1.	Sumatra. Riau Local Wisdom Lubuk larangan, Hutan larangan,	E-Modul. Probelm Based Learning (PBL)	Creative Thinking: Fluency, Flexibility, Originality, Elaboration.

	and Turun boniah.		
2.	Java. Utilisation of medicinal plants by communities around Bromo Tengger Semeru National Park, East Java.	E-Book of Plantae Material. Probelm Based Learning (PBL)	Creative Thinking: Fluency, Flexibility, Originality, Elaboration.
3.	Java. Local Wisdom of Gresik Fishpond Area, East Java	Ecosystem Material E-Book. Problem-based Learning (PBL)	Scientific Reasoning: Theoretical reasoning, Proportional reasoning, Probabilistics Reasoning, Correlational Reasoning.
4.	Java. Surabaya's local wisdom in the form of socioecological manifestations (Sumur Kahuripan where the surrounding trees are sacred, and mangrove forests).	Flipbook. Probelm Based Learning (PBL)	Ethnoconservation
5.	Java. Local wisdom of macroscopic fungi in TAHURA Mojokerto	LKPD. Project Based Learning (PjBL).	Scientific Attitude: Curiosity, critical thinking, co-operation, responsibility, conscientiousness, discipline. Science Literacy: Explain phenomena scientifically, design and evaluate scientific investigations, interpret data and evidence scientifically.
6.	Java. Javanese Cultural Traditions in the Context of Islam (Mutih Fasting).	Test Instrument. HOTS Assessment	Critical Thinking: interpretation, analysis, evaluation, inference, and esplanation.
7.	Java. The ethnoscience of Surabaya's rujak cingur	LKPD. Probelm Based Learning (PBL)	Critical Thinking: interpretation, analysis, evaluation, inference, and esplanation.
8.	Madura. Local wisdom of Bancaran Mangrove Ecotourism (Rokat Tase' custom from the Madurese can be used as a reference to maintain ecosystem balance)	Modules. Probelm Based Learning (PBL)	Critical Thinking: interpretation, analysis, evaluation, inference, and esplanation.
9.	Java. Microgreens Cultivation	Independent Curriculum Teaching Module. Project Based Learning (PjBL)	Bioentrepreneurship: Observation of problems based on scientific studies, Product innovation, Analysis of sales feasibility, Reflection.
10.	Java. Maggot Cultivation	LKM. Case Study	Solving Problems

Based on the data in Table 1, the majority of research is concentrated on Java, particularly East Java, and only 10% of the analyzed theses originated from outside Java. The distribution map of research locations (Figure 2) shows a strong concentration on Java and Sumatra, reflecting students' systematic efforts to explore the sociocultural richness of their immediate surroundings to enrich the biology curriculum at the master's level. The results of this analysis are visualized in Figure 2.

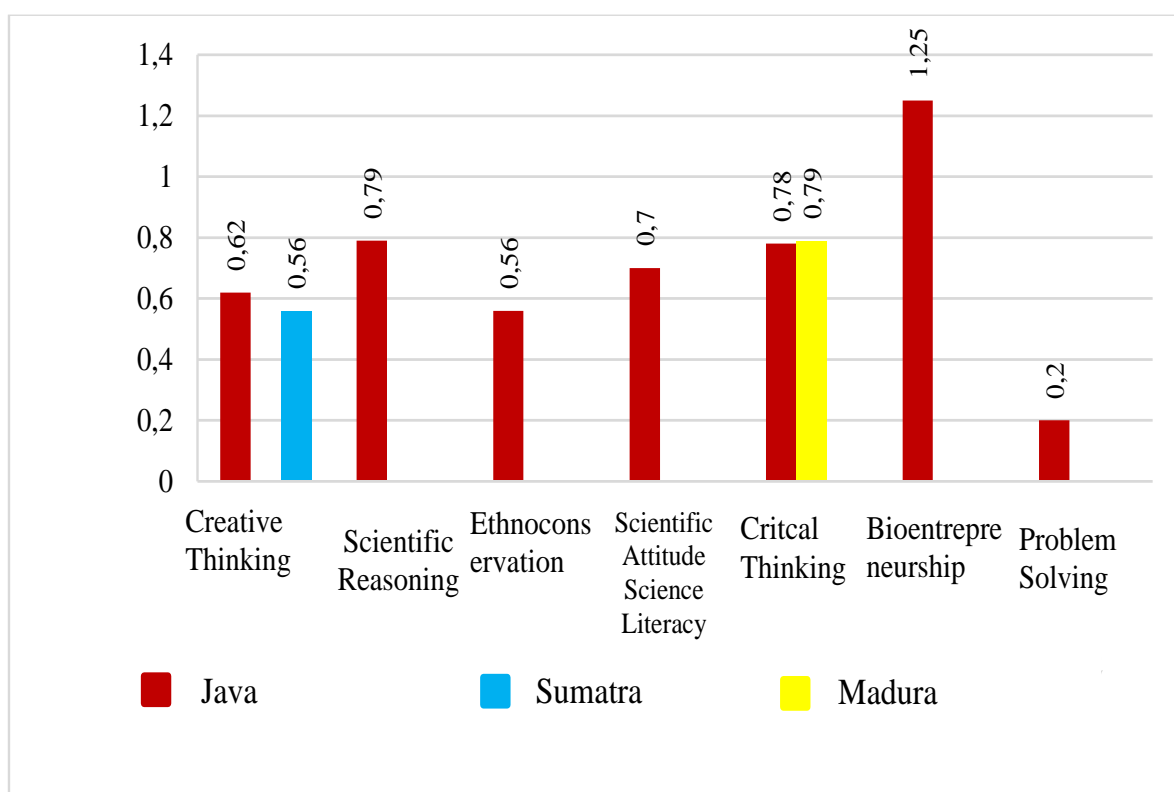
Figure 2. Map of Analysis of Local Wisdom Potential with Distribution in Java and Sumatra Islands Image caption: Red colored dots show the sampling locations of local wisdom in Java, Madura and Riau.



The Relationship of Local Wisdom Mechanisms in Training HOTS

The integration of local wisdom into teaching materials has shown a significant impact on various cognitive dimensions through the activation of students' prior knowledge linked to real-world phenomena. A graph of the effectiveness of integrating local wisdom into teaching materials for training higher-order thinking skills is presented in Figure 3.

Figure 3. Map of Analysis of Local Wisdom Potential with Distribution in Java and Sumatra Islands Image caption: Red coloured dots show the sampling locations of local wisdom in Java, Madura and Riau.



Research related to creative thinking was conducted by integrating local wisdom on natural resource management in Riau and the use of medicinal plants in the Bromo Tengger Semeru National Park (TNBTS). Both were integrated into a Problem-Based Learning (PBL) model and successfully trained students' creative thinking. This proved effective, with an N-gain value of 0.56 for local wisdom on the use of natural materials and 0.62 for the use of medicinal plants around TNBTS.

Scientific reasoning is practiced by integrating local wisdom from ponds in Gresik into an e-book, demonstrating a unique relationship with scientific reasoning skills. The complexity of pond ecosystems requires students to understand the interconnected relationships of variables, such as salinity, temperature, and fish growth. Students must use proportional and probabilistic reasoning to solve the problem of water quality degradation, a highly cognitive process that produces an N-gain of 0.79. This integration demonstrates that a highly technical local context can stimulate deeper scientific logic than pure textbook theory.

Ethnoconservation is taught through an integration of the study of sacred trees in Surabaya and critical thinking skills through the Roket Tase' tradition in Madura. This integration provides a new dimension in developing evaluation and inference skills. Both studies encourage students to analyze the logic behind the tradition of why a tree is considered sacred and why offerings must be released into the sea, often associated with protecting water sources. This critical analysis bridges community beliefs with modern concepts of ecosystems and conservation.

Bioentrepreneurship training involves cultivating microgreens and maggots, demonstrating that local wisdom in food self-sufficiency can be transformed into economic opportunities. The connection between biology and business aspects forces students to think creatively and analytically in assessing product feasibility. The very high effectiveness (N-gain 1.25) in the microgreens material demonstrates that when local wisdom is combined with modern market needs, students' cognitive achievement reaches its optimal level.

DISCUSSION

The integration of local wisdom is consistently able to concretize abstract biology material with the support of pedagogical strategies that are able to facilitate the relationship between formal science and students' sociocultural contexts (Cirkony et al., 2023; Ogegbo & Ramnarain, 2024). The sociocultural phenomena highlighted in the ten analyzed theses serve as cognitive anchors for students. The use of natural materials for everyday life, developed in the form of e-modules, and the use of medicinal plants around TNBTS, East Java, using e-books on Plantae, require flexible thinking to produce creative solutions relevant to the needs of the local community (Aristyasari et al., 2023; Fauziah et al., 2023; Sumarni et al., 2025). Contextual learning with a scientific approach like this provides space for students to be independent in the learning process while strengthening their critical analysis capacity (Arjaya et al., 2024). This is in line with creativity which involves the creation of original and useful ideas (Sternberg & Halpern, 2020).

Scientific reasoning skills showed significant improvement through the study of pond ecosystems in Gresik. The complex structure of pond ecosystems requires students to process the dynamic relationships between variables, such as water quality, fish diet, and microorganism balance, through problem-solving, inference, and evidence-based argumentation (Shofiyah et al., 2024; Zimmerman et al., 2019). This intellectual activity proves that real phenomena can build a deep understanding of concepts so that it can stimulate students' logical and systematic thinking abilities (Guo, 2022; Pownall et al., 2022; Rosyidah, F. et al., 2023).

The conservation contexts explored through the Kahuripan Well in Surabaya and the Bancaran mangrove ecotourism in Madura provide unique contributions to ethnoconservation and critical thinking skills. Students are encouraged to evaluate local traditions through modern science to understand how communities have traditionally maintained ecosystem balance and managed the environment (Lestari et al., 2024). The relationship between spiritual-cultural values and ecological principles awakens students' inferential and explanatory abilities in depth (D. W. Agustina et al., 2023; Arifin et al., 2023). A similar thing happened in the ethnosience study of Rujak Cingur, where the relationship between the composition of traditional food ingredients and the concept of molecular biology or nutrition triggered a very high level of critical thinking (Rufiah et al., 2023).

The development of scientific attitudes and scientific literacy through the use of macroscopic fungi at TAHURA Mojokerto using the Project-Based Learning (PjBL) model demonstrated effectiveness in both affective and cognitive aspects. Students learned to observe biodiversity directly, which in turn fostered a careful, honest, and responsible attitude towards data (Sary et al., 2023). Meanwhile, the implementation of microgreens and maggot cultivation shows a paradigm shift from pure biology to bioentrepreneurship (Supriatno et al., 2023). Local wisdom that is relevant to the needs of the modern market and food security can motivate students to think innovatively and find solutions (Shiyamsyah et al., 2024).

The integration of cultural traditions such as Puasa Mutih in HOTS instruments provides an illustration that culture can become a more relevant learning context and can be applied in everyday life (Sukadari et al., 2023). Although some critical thinking indicators such as inference show varying results, this approach remains effective in helping students understand social contexts more comprehensively (F. D. Agustina et al., 2023). Overall, the success of all these learning models is rooted in the ability of local wisdom to reduce overly abstract cognitive loads (Rosyidah et al., 2025). Local context-based learning creates a more dynamic and relevant learning environment, which ultimately bridges the gap between theoretical knowledge in the classroom and sociocultural realities in society.

Limitations

This study has several limitations that should be considered when interpreting its results. The focus of the study was limited to ten theses by Master of Biology Education students at a single institution, so the geographic distribution of the local wisdom analyzed is still dominated by the island of Java. Sociocultural diversity outside this region, such as in eastern Indonesia, is not widely represented in this analysis map.

CONCLUSION

The integration of Indonesian local wisdom into biology teaching materials has proven to be an effective pedagogical strategy for training higher-order thinking skills (HOTS) at the tertiary level. Mapping results of theses by Master of Biology Education students indicate that local wisdom, ranging from ethnobotany to ethnoconservation, can function as a cognitive bridge that contextualizes complex scientific concepts. The application of problem-based learning (PBL) and project-based learning (PjBL) models rooted in local culture significantly improved students' analytical, evaluation, and creative abilities with a very satisfactory N-gain value. This success confirms that the use of local contexts in science learning serves not only to preserve cultural heritage but also to improve students' intellectual quality. Overall, this study recommends strengthening higher education curricula that are adaptive to local values to produce graduates who are globally competitive while still possessing a strong cultural identity.

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Competing Interests

No potential conflict of interest was reported by the author.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Ethical Approval

Not applicable

Consent To Participate

Not applicable **Consent to Publish** Not applicable

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