CHALLENGES AND OPPORTUNITIES IN THE DEVELOPMENT OF SCIENCE LEARNING MODULES BASED ON LOCAL WISDOM: A SYSTEMATIC LITERATURE REVIEW

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Abstract: Local wisdom-based science learning has emerged as a strategic priority in contextual education; however, its implementation remains restricted. This study seeks to identify obstacles, opportunities, and research trends in the creation of science modules grounded in local wisdom. The employed methodology is a systematic literature review (SLR) utilizing a PRISMA framework, encompassing six Scopus-indexed papers without temporal constraints. The findings indicate that the primary problems consist of inadequate documentation of indigenous knowledge, educators' proficiency in incorporating cultural values, and the discord between contemporary science and traditional beliefs. Opportunities emerge from leveraging local wisdom to improve scientific literacy, critical thinking, and character development. The most recent trend indicates a transition from printed materials to interactive e-modules that integrate cultural values, character development, and project-based learning. This study concludes that local wisdom can function as a teaching foundation to connect culture and contemporary science. Recommendations focus on the creation of culturally sensitive transdisciplinary modules that align with the Merdeka Belajar policy and the Sustainable Development Goals (SDGs) in the framework of inclusive and sustainable education.

Keywords: Local Wisdom, Science Module, Science Literacy, Contextual Learning, Merdeka Belajar, SDGs

INTRODUCTION

Local wisdom plays an important role in the world of education, especially in the learning of Natural Sciences (IPA). The incorporation of local wisdom into educational modules not only augments students' comprehension of science but also fosters cultural preservation and the cultivation of character and critical thinking abilities (Irsan, 2021; Sukiastini, 2024). Modules grounded in local wisdom can reconcile the disparity between scientific theory and practical application, so augmenting students' scientific literacy while linking education to its cultural context (Pamungkas et al., 2017). Culturally based education enhances comprehension of local knowledge's role in science, enriches students' scientific perspectives, and preserves local culture (Jufrida et al., 2020). This method aligns with Indonesia's Merdeka Belajar policy, which promotes flexible learning that is

more relevant and meaningful (Pratami et al., 2023). Culture-based learning contributes to the Sustainable Development Goals (SDGs), especially in relation to quality education and the preservation of local culture (Taptajani et al., 2023).

However, despite its significant potential, the creation of learning modules grounded in local wisdom encounters numerous hurdles. A primary difficulty is the insufficient resources and training for educators to properly incorporate local values into the curriculum (Andaryani, 2023; Mendrofa et al., 2024). Numerous schools, particularly in remote regions, encounter restricted access to culturally relevant instructional materials, hence impacting the efficacy of education (Susilaningtiyas & Falaq, 2021). Additionally, proper tactics are needed to align modern scientific procedures with traditional values so that students do not face confusion in understanding both (Fernando & Yusnan, 2022; Lestari et al., 2024).

The inequity in educational access between urban and rural regions has emerged as a significant concern that directly affects the quality of learning, including the creation of culture-based science modules (Hadi et al., 2020; Tanu, 2016). Urban schools typically possess superior access to technology, expertise, and instructional resources, whereas rural schools remain constrained by inadequate infrastructure. This discrepancy is worsened by problems related to internet connectivity, insufficient digital literacy in the community, and inadequate parental support for children's education (Naufal, 2021; Rianto & Sukmawati, 2021). Numerous schools in isolated areas encounter restricted connectivity and little governmental assistance, hindering their capacity to adapt to advancements in educational technology (Taptajani et al., 2023). Consequently, cooperation between the government and the community is essential to enhance access to technology, teacher training, and the advancement of educational infrastructure (Naufal, 2021).

Conversely, technological improvements and digitalization present substantial prospects for the creation of e-modules grounded in local expertise to improve student involvement in science education. The utilization of multimedia facilitates the presentation of more dynamic and contextual information, enhancing students' comprehension and appreciation of local values in science (Hartatiana & Wardani, 2024; Fadli & Irwanto, 2020). The growing emphasis on culture-based education suggests that incorporating local materials into e-modules can enhance students' critical thinking abilities in scientific and socio-cultural domains (Devina et al., 2023; Faiz & Soleh, 2021; Ramdani et al., 2021).

Technology has emerged as a crucial instrument in facilitating the creation and dissemination of educational modules, particularly for students in geographically challenging locations (Subroto et al., 2023; Widhanarto et al., 2023). E-learning enables educators to present content in an intriguing and contextually pertinent way that corresponds with the local cultural framework (Adrianus et al., 2023; Rizkiana et al., 2021). Subsequent research highlights that culture-oriented e-modules can improve the linkage between education and students' real-world experiences. The participation of community leaders, local practitioners, and cultural stakeholders in the module building process is essential to guarantee the fidelity of the cultural values presented while simultaneously fostering students' sense of ownership in the learning experience and encouraging their active engagement.

Despite extensive research on the incorporation of local wisdom in education, there remains a paucity of systematic studies that delineate specific obstacles and pragmatic answers in the creation of science modules grounded in local culture. Utami et al. (2017) emphasize the significance of incorporating the STEM-A (Science, Technology, Engineering, Mathematics, and Arts) methodology with local values in education. This is significant in the realm of science, as it might enhance pupils' comprehension of the abundance of natural resources in their surroundings. Highlighting the necessity for a rigorous literature evaluation to formulate contextual, sustainable, and evidence-based educational practices (Karim et al., 2024; Lathifah, 2024; Ningsih, 2025; Shofa, 2021). This strategy is pertinent to the SDGs since it fosters cultural preservation, community empowerment, and the improvement of educational quality. The organized learning paradigm grounded in local knowledge facilitates students' critical thinking development by addressing real-life challenges pertinent to their experiences (Ramdiah et al., 2020). However, as noted by Hidayati et al. (2020), more detailed and thorough research is needed to determine how well this strategy works in different situations. Consequently, collaboration among educators, researchers, and stakeholders is essential to develop modules that are both effective and enhance the cultural identity of learners while supporting the objectives of Merdeka Belajar and the SDGs (Wiyani, 2022).

Even though many studies have looked at how to include local wisdom in science education, there is still a lack of detailed research on the real challenges and creative solutions for developing modules, especially when it comes to using digital technology and the Merdeka Belajar policy. Most current research is limited to certain areas and does not adequately tackle the problems of unequal access to technology and teacher training, which greatly affect how well modules work in different locations. This signifies an urgent necessity for more thorough and focused research that identifies limitations and formulates adaptive methods grounded in technology and contemporary policy frameworks. This project aims to fill the current gap by carefully reviewing existing research to find chances, challenges, and current trends in creating effective and sustainable science learning modules that are based on local knowledge. This strategy aims to significantly contribute to educational development in accordance with the ideals of Merdeka Belajar and facilitate the attainment of sustainable development goals (SDGs).

METHOD

This research uses the systematic literature review (SLR) method with the PRISMA approach to make sure the process of choosing literature is organized, clear, and can be repeated, which improves the trustworthiness of the literature review results (Page et al., 2021). We obtained data from the Scopus academic database without time restrictions, using keywords related to "local wisdom in education" and "local wisdom module." Article selection follows the stages of identification, screening, eligibility, and inclusion according to PRISMA and is based on the established inclusion and exclusion criteria (Moher et al., 2009).

The downloaded articles are those that have a research abstract and are fully available. Based on inclusion and exclusion criteria, we determine the selection of

literature for review. The stages of analysis used to determine the articles to be reviewed consist of collecting literature sources from Scopus journals, sorting articles that can be accessed for review, screening articles that can be downloaded in full, to determining the articles to be reviewed based on inclusion and exclusion criteria. These stages are carried out to ensure that the articles to be reviewed are correct and in accordance with the focus of the research being studied (Figure 1)

A. Inclusion:
   1. Discussing science education based on local wisdom at the junior high school level
   2. Articles available in complete PDF format
   3. Available in Indonesian and English

B. Exclusion:
   1. Does not discuss science learning based on local wisdom at the junior high school level
   2. Articles that cannot be accessed in complete PDF format
   3. Not available in Indonesian and English

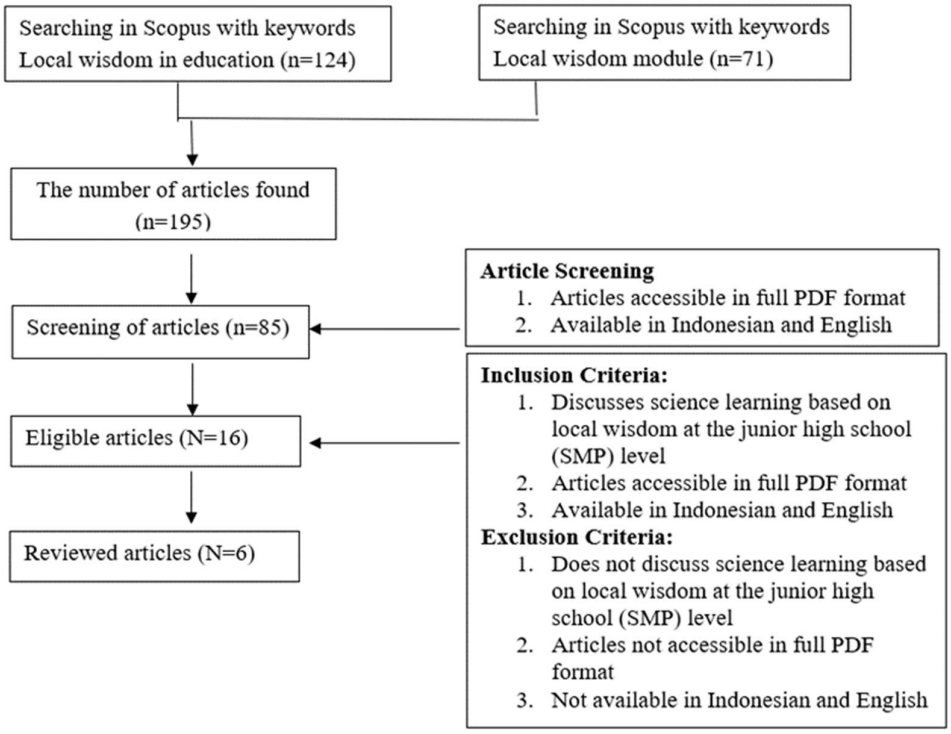

Figure 1. PRISMA diagram for selecting relevant articles

1. RQ 1: What are the main challenges in developing science learning modules based on local wisdom according to existing research?

2. RQ 2: What opportunities does the data provide in the development of local wisdom-based science modules to enhance science literacy and 21st-century skills?
3. RQ 3: What are the trends in research on the development of science modules based on local wisdom according to existing journals?

The data extraction process includes aspects such as the research title, methods, main findings, challenges, and opportunities identified in the development of science modules based on local wisdom. The analysis was conducted using thematic analysis, with stages of theme identification, data synthesis, and evaluation of the reliability of the studies used. To enhance validity, this study employs source triangulation, peer review with education experts and local wisdom, and transparency in documenting the analysis results. However, this study has limitations in the scope of the analyzed studies, so it does not include direct experiments or recent developments outside the reviewed literature.

RESULTS AND DISCUSSION

This research uses Scopus as the primary source to search for literature related to the development of science learning modules based on local wisdom. The search is focused on published articles. We carried out the selection process using the PRISMA method, employing inclusion and exclusion criteria to ensure the analysis of only relevant articles. The selected articles are then categorized based on challenges, opportunities, and current research trends to address the research question.

Table 1. Results of Article Review

Titles	Authors and Years	Publishers
The Development of Local Wisdom-Based Natural Science Module to Improve Science Literation of Students	Setiawan et al. (2017)	Jurnal Pendidikan IPA Indonesia
The Effect of The Science Web Module Integrated on Batik's Local Potential Towards Students' Critical Thinking and Problem Solving (Thinking Skill)	(Putri & Aznam, 2019)	Journal Of Science Learning
Development of Science Module Integrating Local Wisdom of Biotechnology Materials for Class IX Junior High School	(Nabila et al., 2023)	Journal of World Science
The integration of local wisdom with learning innovations in the 'Buddhism' Course for Lower Secondary School Students in Thailand's Educational Opportunity Expansion Schools	(Krualunteerayut et al., 2024)	Journal of Education and Learning

The Effectiveness Of The Local Knowledge-Based Module (LKBM) To Improve Students' Scientific Literacy And Thinking Skills	Uslan, N. Abdullah, M. K. W. Imami, U. Aiman (2024)	Jurnal Pendidikan IPA Indonesia
The Effectiveness of Contextual-Approach Science E-Module Integrated with Local Wisdom on Pressure Topic to Improve Critical Thinking Skills	(Hidayat et al., 2024)	Journal of Innovative Science Education

DISCUSSION

Research in the past decade has shown that the integration of local wisdom in science education significantly contributes to the improvement of educational quality, particularly in terms of science literacy, critical thinking skills, and contextual understanding. However, we review this literature based on three main research questions to obtain a comprehensive picture.

1. RQ1: What are the main challenges in developing local wisdom-based science learning modules based on existing research?

The development of natural science (IPA) learning modules based on local wisdom faces several multidimensional challenges, encompassing conceptual, pedagogical, and structural aspects. The first prominent challenge is the lack of systematic documentation of local knowledge in a format that can be accessed and directly used by educators. Local wisdom is generally passed down orally, is contextual in nature, and is not standardized, making it difficult to integrate into the national curriculum structure, which demands clarity in learning outcomes and assessment indicators. A study by Setiawan et al. (2017) shows that although the communities around Mount Kelud possess local knowledge about disaster mitigation, this information has not yet been formulated into a ready-to-apply learning model. In the context of Situated Learning Theory (Lave & Wenger, 1991) this condition indicates that knowledge not transformed into formal education risks losing its validity as a legitimate learning resource. This research aims to solve the problem by documenting and changing local knowledge that hasn't been included in the learning materials, specifically the traditional game bedi o'o, into an interactive e-module that is organized and easy to measure for teaching purposes.

Additionally, problems arise because modern science, which is based on logic and universal truths, is very different from indigenous knowledge, which is more about symbols, spirituality, and specific contexts. This disparity hinders the incorporation of local cultural values into science education, which necessitates scientific validation. Uslan et al. (2024) note that teachers often avoid including local cultural topics, like the use of Faloak plants, because there aren't enough scientific sources to prove they are valid (Uslan et al., 2024). This study encountered a comparable issue, which was mitigated by an integrative pedagogy method, utilizing the bedi o'o game as a medium to reinforce scientific concepts,

including pressure and Newton's laws. This method creates a link between two different areas of knowledge and shows that local wisdom can be a useful and powerful teaching tool when it is properly connected to scientific and teaching methods. The next challenge relates to the low pedagogical competence of teachers in designing culturally based contextual learning. Teachers tend to have difficulty developing lesson plans (RPP) and teaching media that integrate local values into science education. The study by Krualunteerayut et al. (2024) confirms that teachers in Thailand face obstacles in applying cultural symbols such as "*Sim*" and "*Pha-Wed"* Cloth in Buddhist education. because there has not yet been comprehensive training on culturally based pedagogy. This research introduces a novel project-based learning model that explicitly incorporates local cultural elements into lesson plans and e-modules, ensuring the model is not only narrative but also applicable and replicable across various regional contexts.

In addition, the limited availability of locally based teaching materials also presents a major obstacle. The national textbooks used in various regions are generally generic and do not reflect the local social and cultural realities of the students. Hidayat et al. (2024) show that science teachers in Bima do not have references that reflect local culture, such as the traditional game *bedi o'o*, which is actually very potential to be used as a medium for teaching the concept of pressure in physics. In this study, the issue was addressed by developing and implementing teaching materials based on local culture in the form of e-modules that are not only content-valid but also practical and effective based on the results of tests measuring the improvement of students' critical thinking skills. The paper emphasizes that locally based teaching materials should not be positioned merely as enrichment but rather as an integral part of contextual pedagogical strategies grounded in students' life experiences.

Finally, structural challenges arise from the lack of recognition of local wisdom as a source of formal knowledge within the framework of the national curriculum. Generally, learning achievement indicators and student competency assessments do not explicitly include local wisdom, resulting in its use being optional and non-standardized. In the context of Culturally Relevant Pedagogy (Ladson-billings et al., 2007) the curriculum should reflect the identity, language, and values of the students' community. This research addresses these issues by creating a science module that uses traditional games, linking it directly to science literacy and the Profil Pelajar Pancasila, so that local wisdom is not just an example but a key part of effective and measurable learning.

Overall, these various challenges suggest that additive or symbolic approaches alone cannot resolve the development of science modules based on local wisdom. There is a need for reorientation in curriculum policy formulation, strengthening teacher competencies, and developing learning resources that appreciate cultural diversity as an epistemological foundation. This research helps by providing a combined method that records, relates, and incorporates local wisdom into creating science lessons that are transformative, human-centered, and suitable for 21st-century education.

2. RQ 2: What opportunities can be leveraged in the development of science modules based on local wisdom to enhance science literacy and 21st-century skills?

Using local wisdom in creating science learning modules is a teaching method that not only considers the social and cultural background but also effectively promotes science literacy and 21st-century skills at the same time. In the realm of contemporary education, science literacy is no longer limited to conceptual aspects alone but has shifted toward strengthening critical thinking skills, contextual problem-solving, collaboration, scientific communication, and ethical awareness in the use of knowledge. In this framework, local wisdom presents transformative opportunities because it is directly rooted in the social practices and cultural ecology of students while also holding the potential for values and narratives that can be transformed into authentic experiential learning tools.

Several previous studies have indicated the positive contribution of integrating cultural context in science education. Setiawan et al. (2017), for example, showed that event-based learning, such as the eruption of Mount Kelud, can enhance students' understanding of geoscience concepts. However, the focus of the research is still limited to cognitive aspects and has not directed the learning approach toward the development of soft skills such as collaboration, communication, and critical reflection. Similarly, Putri and Aznam (2019) integrated batik motifs into web-based science modules and noted an improvement in critical thinking skills. However, the visual and symbolic approaches they used have not explicitly utilized cultural potential as a learning activity that is social, reflective, and transdisciplinary.

Other studies reviewed, such as Uslan et al. (2024) and Nabila et al. (2023), show that the development of science modules based on local plants and fermented foods can provide a learning experience that is closer to the students' reality. However, these modules still emphasize mastery of the material and have not yet systematically integrated cultural values into the formation of students' scientific character, such as social responsibility, integrity, and ecological awareness. On the other hand, the study by Krualunteerayut et al. (2024) shows that cultural symbols can be utilized to form values and attitudes through religious education, but this approach has not yet been widely adopted in the design of science learning, even though ideal science literacy should also encompass affective and ethical aspects within the scientific dimension.

Hidayat et al. (2024) conducted a study that explores the ideal integration of culture, science literacy, and the enhancement of higher-order thinking skills by developing an IPA e-module based on the traditional game bedi o'o. Studies have proven that the module significantly enhances students' critical thinking skills. Nevertheless, the explicit mapping of 21st-century skill dimensions, as well as alignment with the elements of the Profil Pelajar Pancasila, remains an open area that can be further expanded. This data shows that, overall, earlier studies have not created learning plans that include local wisdom as a teaching method combined with project-based learning and the development of cross-disciplinary skills.

The new idea in this research is combining the Culturally Responsive Teaching framework, hands-on learning, and the 21st-century skills framework in

creating a science education program. The developed module is not only valid and practical but also functionally represents a learning model that is responsive to the local context while being compatible with global demands. This research significantly adds to the conversation about science education that considers culture by offering teaching methods that are innovative, thoughtful, and useful for improving students' understanding and skills in science.

3. RQ 3: Research Trends in Developing Science Learning Modules Based on Local Wisdom

In the past ten years, interest in research developing science learning modules based on local wisdom has continued to increase. This development aligns with the evolving direction of education, which emphasizes the importance of learning that is consistent with students' cultural contexts, character formation, and the cultivation of 21st-century skills such as critical thinking, collaboration, and communication. In this literature review, the researchers did not set a specific time limit for the article search. This is done because the number of publications specifically discussing local wisdom-based science modules in reputable journals like Scopus is still limited. Therefore, the methodology employed involves selecting articles based on their substance and relevance to the subject matter, rather than the year of publication, to get more diversified and comprehensive study material.

The research indicates that preliminary investigations continue to concentrate on investigating and presenting the potential of local culture as a resource in science education. The research conducted by Setiawan et al. (2017) employed the eruption of Mount Kelud to elucidate geoscience principles. Additional research has commenced the development of more tangible modules, such as printed modules focused on local fermented foods (Ballenger & Jiang, 2023) or traditional plants (Uslan et al., 2024). While these studies have integrated local culture into the module material, they predominantly concentrate on comprehending scientific concepts and have yet to prioritize 21st-century abilities.

Recently, the trajectory of research has begun to shift. A multitude of scholars are currently creating digital modules grounded in indigenous knowledge, supplemented by more dynamic pedagogical methods, such as project-based learning. Hidayat et al. (2024) developed a scientific e-module utilizing the traditional game bedi o'o to elucidate the notion of pressure in physics. This subject aims to foster collaboration, innovation, and analytical thinking skills among students. Furthermore, an escalating number of research endeavors are associating local cultural values with the Profil Pelajar Pancasila, ensuring that education encompasses not only scientific knowledge but also the cultivation of students' attitudes and character.

Despite the low number of studies on this subject, the current findings suggest that scientific modules grounded in indigenous wisdom possess significant potential for further advancement. These modules not only enhance students' comprehension of the lectures by aligning with their daily experiences, but they also cultivate essential social skills and cultural values. This project seeks to enhance that tendency by creating a science module that transmits scientific content

while fostering students' recognition and appreciation of their local culture through active and meaningful learning.

CONCLUSION

The creation of science learning modules based on local knowledge encounters major challenges, especially the lack of structured teaching materials and inadequate training for including cultural aspects. This approach offers significant opportunities by situating science education within local values; therefore, it improves scientific literacy and cultivates 21st-century abilities. Methods like project-based learning and conventional games have demonstrated efficacy in linking scientific concepts to students' real-world experiences. Current trends suggest a shift toward interactive digital modules that include character education and the principles of Profil Pelajar Pancasila.

So, the government should take steps to help record and digitize local knowledge, provide training for teachers, and add culturally relevant science lessons to national education policy. These endeavors are crucial for promoting the Merdeka Belajar program and the Sustainable Development Goals (SDGs), thereby fostering a more inclusive, forward-thinking, and culturally relevant science education.

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