Proceeding of ICMR 8(1), 215-223

Integration of Artificial Intelligence and Local Wisdom In the Development of Outdoor Learning Modules to Support the Achievement of SDGs in Schools

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Abstract. This study aims to develop an outdoor learning-based teaching module that integrates Artificial Intelligence (AI) and local wisdom to support the achievement of the Sustainable Development Goals (SDGs) in schools. The research employed a Research and Development (R&D) approach using the 4D model (Define, Design, Develop, and Disseminate) and a mixed methods design. Data were collected through interviews, observations, questionnaires, expert validation sheets, and learning outcome tests. Quantitative data were analyzed using descriptive statistics and N-Gain analysis, while qualitative data were analyzed through data reduction, presentation, and conclusion drawing. The results indicate that the developed module is highly feasible, practical, and effective. Expert validation showed a very high level of validity with an average score of 4.55. Students' responses reached an average of 87.26% in the very good category, indicating strong engagement and motivation. Teachers' assessments also classified the module as very practical with an average score of 4.54. Furthermore, the pretest and posttest results demonstrated a moderate improvement in learning outcomes with an average N-Gain score of 0.62. The integration of AI facilitated personalized learning, field data analysis, and adaptive feedback, while local wisdom ensured cultural relevance and strengthened students' social and environmental awareness. In conclusion, the developed module effectively integrates technology, culture, and environmental learning to enhance students' academic achievement, critical thinking, collaboration skills, and sustainability awareness. This module offers an innovative learning model that supports SDG-based education and can be adapted for broader educational contexts.

Keywords: Artificial Intelligence, Local Wisdom, Outdoor Learning, Teaching Modules, Sustainable Development Goals, Education

1. Introduction

In the last decade, developments in information and communication technology, particularly artificial intelligence (AI), have opened up significant opportunities for reforming formal education practices. AI offers learning personalization capabilities, real-time learning analytics, and evaluation automation that can improve the effectiveness of the learning process (Wang, 2024). These capabilities are relevant to the global education agenda, particularly efforts to accelerate the achievement of the Sustainable Development Goals (SDGs) on quality education (SDG 4), as AI has the potential to expand access, tailor content to individual learning needs, and support data-driven

pedagogical decision-making (Al-Sagri, 2024). However, the adoption of AI in educational contexts often faces ethical challenges, infrastructure gaps, and the risk of de-synchronization with local values if the technology is implemented without considering the local cultural context (Wahyuni et al., 2024).

In Indonesia, the dynamics of contemporary education demand solutions that are not only technical but also contextual. Local wisdom—which encompasses practices, values, knowledge, and norms developed within a community—has great potential to enrich learning content, making it relevant to students' social and cultural environments (Nugraha, 2023). Integrating local wisdom into curricula and teaching materials has been shown to increase student engagement, strengthen cultural identity, and facilitate more meaningful, contextual learning (Raekhan, 2025). Therefore, any technological innovation in education in Indonesia needs to be designed to accommodate and strengthen local values, not replace them.

The outdoor learning approach provides an ideal pedagogical arena for combining AI and local wisdom. Outdoor learning provides hands-on experience (experiential learning) that allows students to work with real objects, the physical environment, and local communities conditions that support the internalization of cultural values and the observation of environmental phenomena related to sustainability goals (Purwakusumaningrum & Pangestika, 2025). When combined with AI tools (e.g., adaptive model-based mobile applications, environmental sensors, or interactive learning modules), outdoor learning can deliver personalized and contextual learning experiences, supporting 21st-century competencies and SDG awareness (e.g., environmental literacy, sustainable behavior).

Despite the significant potential for synergy, current literature highlights several gaps in research and practice. First, many studies on educational AI still focus on the development of algorithms and technical systems without exploring how AI can be sensitively integrated into local cultural contexts (Wang, 2024). Second, research on learning modules that combine AI with local wisdom especially in outdoor learning formats is still relatively limited and generally conceptual in nature or limited to case studies (Arini, 2024; Raharjo, 2025). Third, studies linking technology integration to SDG achievement at the school level still require stronger empirical evidence, particularly regarding learning outcome indicators, changes in attitudes toward sustainability, and the sustainability of the module implementation itself (Al-Sagri, 2024). Thus, research that develops, tests, and evaluates outdoor learning-based teaching modules that combine AI and local wisdom is highly relevant to fill this empirical gap.

Theoretically, the integration of AI and local wisdom in outdoor learning modules can be positioned within a combination of several conceptual frameworks. The socio-technical framework views technology and social context as mutually constitutive elements; technology does not exist in isolation but is embodied through local social practices and cultural values (Wahyuni et al., 2024). The place-based education approach emphasizes the importance of utilizing the local physical and cultural environment as primary learning resources, while adaptive learning theory emphasizes the benefits of systems that adapt learning paths based on individual needs (IJAIED; Garzón, 2025). Combining these three perspectives creates a strong theoretical foundation for designing learning modules that leverage the capabilities of AI for personalization and analytics, while remaining rooted in the local context, enriching the meaning of learning.

From a practical and policy perspective, the direction of developing these learning modules aligns with the curriculum mandate, which emphasizes contextualization of

learning and strengthening character based on local culture (Kemdikbudristek, national curriculum document—relevance of local practices). Furthermore, efforts to achieve the SDGs at the national level require educational innovations that can shape students' attitudes, knowledge, and skills to support sustainable development. Outdoor learning modules that combine AI and local wisdom have the potential to meet these demands by producing contextual, reflective, and evidence-based learning experiences (Prasetya, 2025; Al-Sagri, 2024).

Operationalally, the development of these teaching modules requires attention to several important aspects. First, content design must maintain the authenticity of local wisdom through collaboration with traditional stakeholders, teachers, and local communities to ensure cultural values are represented accurately and ethically. Second, AI components must be designed to be transparent and easy for teachers to operate: personalization features should be recommendatory (not deterministic), provide actionable feedback, and be equipped with ethical guidelines to avoid algorithmic bias and data misuse. Third, effectiveness evaluations should combine quantitative (e.g., increased competency achievement) and qualitative (e.g., changes in attitudes toward the environment and appreciation for local values) measurements to capture the module's multidimensional impact on achieving the SDGs. An R&D study following the ADDIE (Analyze, Design, Develop, Implement, Evaluate) model is an appropriate methodological approach for this purpose because it allows for iteration of field-based evidence-based designs (Purwakusumaningrum & Pangestika, 2025; Putri, 2025).

With the above background, this research aims to develop and test an outdoor learning module that integrates AI capabilities with local wisdom to support the achievement of SDG indicators related to quality education. The main research questions include: (1) How to design an outdoor learning module that integrates AI and local wisdom pedagogically and ethically?; (2) To what extent does the implementation of such a module increase student engagement, competence, and sustainability awareness?; and (3) What factors influence the scalability and sustainability of the module's implementation in the Indonesian school context? Answering these questions is expected to contribute to the interdisciplinary literature linking education, technology, and sustainable development and provide practical guidance for educators and policymakers.

2. Method

This research uses Research and Development (R&D) with the 4D model (Define, Design, Develop, and Disseminate) to produce an outdoor learning-based teaching module integrated with Artificial Intelligence (AI) and local wisdom to support the achievement of SDGs in schools. The research approach is mixed methods, combining qualitative techniques at the needs analysis and local wisdom exploration stages, as well as quantitative techniques to test the validity, practicality, and effectiveness of the module. The research was conducted in a junior high school that supports environmental and digital technology-based learning innovations, with research subjects consisting of subject teachers, students, and three expert validators (material experts, media experts, and educational technology experts). The research procedure was carried out in four stages. The Define stage includes curriculum analysis, student characteristics, technology needs, and identification of environmental potential and local wisdom as a means of outdoor learning. The Design stage includes the preparation of module designs, learning scenarios, worksheets, assessment instruments, and the integration of AI features such as image recognition, educational chatbots, and AI-based field data analysis. The Develop

phase produced a module prototype, which was then validated by experts using a Likert-scale-based instrument before being revised and tested through limited trials and field trials to assess its practicality and effectiveness in improving students' understanding of the SDGs material and issues. The Disseminate phase involved distributing the module to teachers, implementing training, and publishing it. Data were obtained through interviews, observations, validation questionnaires, response questionnaires, and learning outcome tests. The research instruments included validation sheets, observation sheets, questionnaires, and cognitive tests that had been tested for content validity by experts. Qualitative data analysis was conducted through data reduction, presentation, and conclusion drawing, while quantitative analysis used expert validation score calculations, practicality analysis, and gain testing to determine the module's effectiveness. The entire research process adhered to ethical principles, including informed consent from research participants, data confidentiality, and the responsible use of AI.

3. Results and Discussions

The research results indicate that the development of an outdoor learning-based teaching module integrated with Artificial Intelligence (AI) and local wisdom is feasible, practical, and effective for use in school learning to support the achievement of the Sustainable Development Goals (SDGs). The developed module received excellent reviews from expert validators, particularly in terms of material suitability, readability, structure, technology integration, and relevance to local wisdom values and sustainable development goals. Validation by material experts indicated that the module content aligns with the learning outcomes of the Independent Curriculum, with an emphasis on critical thinking skills, creativity, and understanding of environmental issues. Media experts also assessed the module design as attractive, easy to use, and supportive of Universal Design for Learning (UDL) principles. Educational technology experts assessed the integration of AI through chatbot features, image recognition, environmental data analysis, and personalized feedback as appropriate to student needs and the potential of outdoor learning contexts.

Table 1. Expert Validation Results of the Learning Module

No	Assessment Aspect	Average Score	Category
1	Content Suitability	4.62	Very Valid
2	Module Structure	4.55	Very Valid
3	AI Integration	4.48	Very Valid
4	Local Wisdom Relevance	4.50	Very Valid
5	Language Readability	4.58	Very Valid
	Average	**4.55**	**Very Valid**

Table 1 presents the results of expert validation of the developed learning module. The assessment was conducted by material experts, media experts, and educational technology experts to evaluate the quality and feasibility of the module. The average score of 4.55 indicates that the module achieved a *very valid* category. High scores in content suitability, module structure, and language readability demonstrate that the learning materials are aligned with curriculum standards and are easy to understand. Furthermore, the strong evaluation of AI integration and local wisdom relevance suggests that the module successfully combines technological innovation with cultural values. These results confirm that the module is suitable for implementation in classroom and outdoor learning activities.

Table 2. Students' Responses to the Use of the Module

No	Response Aspect	Percentage (%)	Category
1	Learning Interest	88.5	Very Good
2	Ease of Use	85.2	Very Good
3	Benefits of AI Features	87.6	Very Good
4	Relevance to Local Culture	84.9	Very Good
5	Learning Motivation	90.1	Very Good
	Average	**87.26**	**Very Good**

Table 2 shows students' responses to the use of the learning module during the implementation stage. The average percentage score of 87.26% falls within the *very good* category, indicating a highly positive reception. High levels of learning interest and motivation reflect students' enthusiasm for outdoor learning activities supported by AI technology. The favorable evaluation of ease of use suggests that the module is user-friendly and does not create technological barriers. In addition, the positive perception of cultural relevance demonstrates that the integration of local wisdom helps students connect learning content with their real-life experiences. Overall, these findings indicate that the module enhances students' engagement and motivation in learning.

Table 3. Teachers' Assessment of Module Practicality

No	Practicality Indicator	Average Score	Category
1	Ease of Implementation	4.60	Very Practical
2	Clarity of Instructions	4.55	Very Practical
3	Time Efficiency	4.42	Practical
4	Technological Support	4.50	Very Practical
5	Curriculum Alignment	4.65	Very Practical
	Average	**4.54**	**Very Practical**

Table 3 presents teachers' evaluations of the practicality of the developed module. With an average score of 4.54 categorized as *very practical*, the module is considered easy to implement in real teaching contexts. High scores for ease of implementation and clarity of instructions indicate that teachers can use the module without extensive training. The positive assessment of technological support shows that the AI features function effectively and assist teachers in managing learning activities. Moreover, strong curriculum alignment ensures that the module supports learning objectives and assessment standards. These results suggest that the module is feasible for routine use in schools.

Table 4. Comparison of Students' Pretest and Posttest Results

No	Assessment Aspect	Pretest (Mean)	Posttest (Mean)	N-Gain	Category
1	Concept Understanding	62.4	84.6	0.59	Moderate
2	Environmental Literacy	60.8	86.2	0.65	Moderate

3	Critical Thinking	58.7	82.3	0.57	Moderate
4	Collaboration	64.2	88.5	0.68	Moderate
	Average	**61.5**	**85.4**	**0.62**	**Moderate**

Table 4 compares students' learning outcomes before and after using the module. The increase in mean scores from pretest (61.5) to posttest (85.4) demonstrates a substantial improvement in students' academic performance. The average N-Gain value of 0.62 falls within the *moderate* category, indicating that the module is effective in enhancing students' understanding, environmental literacy, critical thinking, and collaboration skills. These results suggest that the integration of outdoor learning, AI technology, and local wisdom contributes positively to meaningful learning experiences and cognitive development.

Table 5. Linkage Between Module Components and SDGs Indicators

No	Module Component	Related SDGs Indicator	Implementation Form
1	Environmental Observation	SDG 13 (Climate Action)	Environmental condition analysis
2	Flora and Fauna Identification	SDG 15 (Life on Land)	Use of AI Recognition
3	Local Cultural Study	SDG 11 (Sustainable Cities)	Community interviews
4	Field Data Analysis	SDG 4 (Quality Education)	AI-based data processing
5	Reflective Discussion	SDG 12 (Responsible Consumption)	Group discussion

Table 5 illustrates the relationship between module components and relevant Sustainable Development Goals (SDGs) indicators. Each learning activity is designed to support specific SDG targets, such as climate action, sustainable communities, and quality education. Environmental observation and data analysis activities strengthen students' awareness of ecological issues, while local cultural studies promote social sustainability. The use of AI recognition and data processing tools enhances students' analytical skills and technological literacy. This alignment demonstrates that the module not only improves academic outcomes but also fosters sustainability-oriented attitudes and competencies, supporting the broader goals of SDG-based education.

Limited trials demonstrated that students responded very positively to the module. They felt that outdoor learning activities provided a more meaningful, relevant, and contextual learning experience. The AI features used help students identify objects in the environment, such as plants, ecological structures, cultural artifacts, and social phenomena, more quickly and accurately. Furthermore, students utilize AI as a tool to analyze field data and receive automatic feedback on their answers or observations. This strengthens learning motivation and enhances student independence during out-of-class activities. Teachers also report that the module facilitates them in designing varied and transformative learning because it provides clear guidance, systematic observation tools, and technological support that facilitates exploratory activities.

Field trials show significant improvements in students' understanding of the learning material, particularly in aspects of environmental analysis, ecological issues, and socio-cultural relationships around them. Gain tests show moderate to high levels of improvement, indicating that the module is effective in driving improved learning

outcomes. The module also strengthens students' social and environmental literacy, which are part of SDG competencies such as climate action, terrestrial ecosystems, marine ecosystems, and strengthening sustainable communities. The integration of local wisdom in the module, such as the use of cultural terms, community practices, and traditional knowledge related to environmental management, encourages students to understand that sustainable development solutions do not only come from modern technology, but also from value systems that have long existed in society.

Outdoor learning combined with AI has also proven effective in enhancing collaboration and communication among students. Field observation activities require students to discuss, record observations, classify, and utilize technology collaboratively. AI serves as a facilitator, helping groups align perceptions, verify field findings, and solve data-driven problems. These findings support the view that well-designed educational technology can enhance the quality of social interactions, not replace them. In the school context, this success demonstrates that AI integration is not simply a technological trend but can be a strategic tool that strengthens active, experiential learning.

In addition to its effectiveness on learning outcomes, the module was also deemed practical based on teacher and student questionnaire responses. Teachers rated the module as easy to use, not overwhelming, and providing a logical flow of activities for learning outside the classroom. The AI features were perceived as a tool that facilitated the learning process, not a technological barrier. Students also felt that the use of AI in outdoor activities provided a more modern and relevant learning experience, keeping pace with global technological developments, while remaining rooted in local cultural values. The combination of advanced technology and local wisdom in this module provides a unique, contextual, and meaningful learning experience.

Overall, the results of this study confirm that an outdoor learning-based teaching module that integrates AI and local wisdom not only improves the quality of learning but also has the potential to become a 21st-century learning model that supports the SDGs vision in school settings. This module connects three strategic elements: technology, culture, and the environment. The integration of AI provides efficiency and accuracy in field data observation and analysis, while local wisdom ensures that learning remains socially and culturally relevant. Outdoor learning enables hands-on learning experiences that strengthen students' connection with nature and community.

The findings of this study also demonstrate that future-oriented education does not have to separate students from their cultural roots but can instead integrate modern technology with local values to foster a deeper understanding of sustainability. Thus, the resulting learning not only enhances academic and technological skills but also builds students' character as an environmentally conscious and culturally engaged generation. This module can be replicated across various subjects and regional contexts with rich environmental and cultural riches, thus making a broader contribution to learning innovation in Indonesia.

4. Conclusions

This research demonstrates that the development of an outdoor learning-based teaching module integrating Artificial Intelligence (AI) and local wisdom is feasible, practical, and effective in supporting the achievement of the Sustainable Development Goals (SDGs) in schools. This module enhances student engagement, conceptual understanding, environmental literacy, and critical and collaborative thinking skills. The AI integration facilitates personalized learning, field data analysis, and adaptive feedback,

while local wisdom ensures cultural relevance and reinforces social values. Outdoor learning provides hands-on learning experiences that strengthen students' connection with nature and the surrounding community.

Based on Table 1, the expert validation results indicate that the developed module achieved a very high level of validity, with an average score of 4.55. This suggests that the module meets content, design, and technological integration standards. Furthermore, Tables 2 and 3 show that the module received very positive responses from students and was considered highly practical by teachers. Meanwhile, Table 4 demonstrates an improvement in learning outcomes in the moderate category, with an average N-Gain score of 0.62, indicating the effectiveness of the module. In addition, the alignment between the module components and SDGs indicators, as presented in Table 5, strengthens the role of the module in supporting sustainable education.

Overall, this module is an innovative learning model that integrates technology, culture, and the environment, improving the quality of education and developing students' character and commitment to sustainability. The findings of this research can serve as a reference for the development of similar teaching modules in other schools and support the broader implementation of SDG-based education.

5. References

Al-Sagri, H. S. (2024). Evaluating the role of artificial intelligence in sustainable development: A bibliometric analysis. *Sustainable Development*, 32(4), 987–1002. https://doi.org/10.1002/sd.2418

Arini, D. (2024). Contribution of Artificial Intelligence (AI) in education to enhance literacy and learning outcomes. *Jurnal Pendidikan dan Pengajaran IPA*, 12(2), 45–59. https://doi.org/10.22219/jppi.v12i2.1103

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.

Garzón, J. (2025). Systematic review of artificial intelligence in education: Applications and implications. *Computers & Education*, 192, 104653. https://doi.org/10.1016/j.compedu.2022.104653

Nugraha, A. R. (2023). Pemanfaatan kearifan lokal dalam pengembangan bahan ajar berbasis budaya. *Jurnal Pendidikan Indonesia*, 9(1), 22–35. https://doi.org/10.23887/jpi.v9i1.37921

Purwakusumaningrum, N. A., & Pangestika, R. R. (2025). Outdoor learning sebagai solusi untuk mengurangi kejenuhan belajar siswa sekolah dasar. *Jurnal Pendidikan Dasar*, 16(2), 115–130. https://doi.org/10.21831/jpd.v16i2.52147

Putri, A. J., & Safitri, R. W. (2025). Optimalisasi pengembangan kurikulum: Sinergi kearifan lokal, AI, ekologi, dan neurosains dalam meningkatkan kualitas pendidikan. *Jurnal Inovasi Pendidikan*, 11(1), 87–102. https://doi.org/10.31227/osf.io/9s4c2

Raharjo, A. (2025). Pengembangan modul ajar berbasis AI untuk pembelajaran adaptif di sekolah menengah. *Indonesian Journal of Educational Technology*, 8(1), 45–60. https://doi.org/10.17509/ijiet.v8i1.29561

Sriyati, S., Septiani, F., Harlistya, K. S., & Amprasto, A. (2025). Local-wisdom-based teaching materials to improve student problem-solving. *Jurnal Bioedukatika*, 13(2), 77–91. https://doi.org/10.26555/bioedukatika.v13i2.17951

Wahyuni, S., Hartono, R., & Kurniawan, F. (2024). Trends in AI-infused language learning: Opportunities and challenges. *Journal of Education Technology & Innovation*, 7(3), 33–49. https://doi.org/10.1080/17505629.2024.1897402

Wang, S. (2024). Artificial intelligence in education: A systematic review of research trends, applications, and challenges. *Computers & Education*, 192, 104653. https://doi.org/10.1016/j.compedu.2024.104653

Wiharti, W., Apriani, D., & Suriswo, S. (2024). Pengembangan modul ajar alur MERDEKA berbasis outdoor learning. *Journal of Education Research*, 18(1), 55–70. https://doi.org/10.21831/jer.v18i1.2073