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Development of Integrated Science Learning Modules Integrated with Local Wisdom to Improve Science Literacy

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Abstract: This study aims to develop an integrated science learning module that integrates local wisdom from the megalithic sites in the Bada Valley to improve science literacy and critical thinking skills among students at Al-Khairaat 2 Palu Junior High School. The main problems are low science literacy among students and minimal utilization of local potential in science learning. The method used was Research and Development (R&D) with the ADDIE model, which includes analysis, design, development, implementation, and evaluation. Data were collected through expert validation, practicality questionnaires, and effectiveness tests with a sample of students and school teachers. Analysis was conducted based on the validity, practicality, and effectiveness of the module using Cohen's d to measure the improvement in students' skills. The validation results showed that the module was valid and practical to use, with a high effectiveness score (0.87). The use of the module significantly improved students' science literacy in the indicators of explaining scientific phenomena, evaluating scientific investigations, and interpreting data, with average scores of 89%, 76%, and 60%. In conclusion, this local wisdom-based science learning module is effective in improving the quality of science learning, science literacy, and students' critical thinking skills, as well as strengthening their character and concern for the surrounding culture and environment.

Keywords: Central Sulawesi megalithic site; Integrated science learning module; Local wisdom; Science literacy

Introduction

Regional potential can be utilized as a learning medium and learning resource. By utilizing the potential of the region can gain experience directly using learning resources that exist in the school environment (Anisa et al., 2017). The incorporation of local potential into learners' educational experiences significantly enhances students' understanding of academic content in relation to students' daily lives, while simultaneously encouraging increased interest in educational pursuits and facilitating the achievement of specified learning objectives. It is imperative for educators to effectively utilize local potential within the instructional framework, as this approach assists students in understanding contextual concepts and examples, thereby improving students' cognitive abilities, skill sets and overall attitude towards learning (Nurjanah et al., 2024).

In practice, integrating local potential into science education has various objectives, ranging from strengthening concepts and meaningful learning, developing thinking skills, developing problem-solving skills, and other skills (Latip et al., 2024). Meanwhile, integrating local potential into the educational framework improves students' scientific process competencies and conceptual understanding, promotes active learning, and encourages practical application in real-world scenarios; this not only improves academic

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proficiency but also fosters cultural awareness (Qomariyah & Setiawan, 2022).

The utilization of local potential in learning is essential, particularly in the development of learning tools. One such learning tool is a module packaged as teaching material. Learning resources can be obtained by utilizing local potential around the school. This aligns with the Ministry of Education and Culture of the Republic of Indonesia Regulation No. 103 of 2014 on Learning in Basic and Secondary Education, which states that "Learning is a process of interaction among students and between students and educators, as well as with learning resources within a learning environment." (Mendikbud, 2014).

Integrating this local wisdom into science learning modules can provide a more contextual and relevant approach for students, thereby improving their understanding and memory. This makes explaining natural phenomena, such as geological processes, ecosystems, and interactions between humans and the environment, more interactive. As a result, students not only learn about science from a scientific perspective but also gain an understanding of the cultural and social values embedded in local wisdom (Ismail, 2024).

Efforts to develop learning materials and teaching materials used by schools are generally not based on local wisdom, particularly the lack of teaching materials in the form of modules, especially those based on local wisdom (Widiya et al., 2021). Learning media and teaching materials are aspects or components that should be prioritized in the teaching and learning process. These two things are important parts used in the learning process. The presentation of material in the module is adapted to the approach used, namely the contextual approach, which has seven distinctive characteristics (Gita et al., 2018).

Based on field data, the science literacy skills of students in Indonesia are below the PISA average. Science literacy skills can be developed through learning that refers to culture (Junita & Yuliani, 2022). Therefore, educators are required to improve students' science literacy skills, thereby facilitating the development of students' understanding of scientific concepts and critical analytical skills, enabling them to keep pace with the times (Andini et al., 2022). The science literacy skills of every individual need to be improved, especially among students. One alternative to improve science literacy skills among students is to apply a learning approach that can motivate students to be interested in participating in the learning process (Rohmah et al., 2019).

In addition to low literacy levels, another issue was found in science lessons on ecosystems, where teachers only used textbooks and lectures without using more interactive approaches, including exploring the natural environment. This resulted in a lack of critical, creative, and innovative thinking skills during the learning process. Therefore, an approach based on learning around students is needed.

Therefore, the development of a science learning module based on the local wisdom of the thousand megaliths of Central Sulawesi is a strategic step in improving the quality of education in Indonesia. In addition to providing relevant scientific knowledge, this module is also expected to shape students' character to love culture and the environment. Through contextual and integrative learning, students will be better prepared to face future challenges and contribute positively to society.

Based on the above discussion, the researcher will develop instructional materials in the form of integrated science learning modules incorporating local wisdom as an alternative solution to the issues outlined. Through these modules, teachers can connect learning experiences, making the learning process more meaningful, enjoyable, and easier to understand.

Method

This research is a Research and Development (R&D) study. R&D research is used to obtain specific products and aims to test the effectiveness of the products obtained. This research was conducted from April to June 2025 at Al-Khairaat 2 Junior High School in Palu, Central Sulawesi, with seventh-grade students as the research subjects. This research used the Research and Development (R&D) method, which aimed to produce an integrated science learning module and test the effectiveness of the product in improving students' science literacy and critical thinking skills. The research design uses a model developed by (Branch & Kopcha, 2014), namely ADDIE, which consists of five stages, namely Analyze, Design, Development, Implementation, and Evaluation, which can be illustrated as shown in Figure 1.

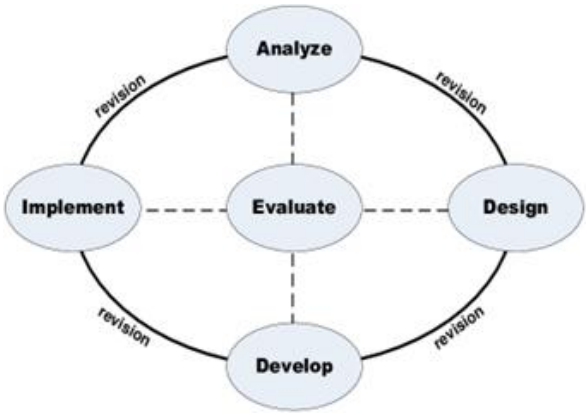

Figure 1. ADDIE development flow

Data were collected using various instruments, namely expert validation sheets to assess the validity of the modules, practicality questionnaires filled out by teachers and students to assess the ease of use of the modules, and effectiveness tests in the form of pre-tests and post-tests to measure the increase in students' science literacy after using the modules. Data analysis was performed by calculating the validity and practicality percentages and using Cohen's d formula to measure the effect of module use on learning outcome improvement.

Data analysis was carried out by calculating the validity percentage (Table 1) and practicality (Table 2), as well as the effectiveness of the module using Cohen's d formula (Table 3). Data collection techniques included questionnaires, observations, tests, and documentation, while research instruments consisted of expert validation sheets, practicality questionnaires, and pretest and posttest questions. Then, the increase in science literacy was observed using the interpretation category to determine the level of influence of module use on these skills.

The validation data for the Learning module was obtained from the results of validation by experts using a validation sheet instrument that can be analyzed based on validity criteria (Nurdini & Wardana, 2024).

Table 1. Validity Critera (Nurdini & Wardana, 2024)

Percentage	Criteria
81%-100%	Very Valid
61%-80%	Valid
41%-60%	Less Valid
21%-40%	Not Valid
0%-20%	Very Not Valid

The practicality of using the learning module product was analyzed based on the results of student response questionnaires and teacher response questionnaires. The data on the implementation of learning was analyzed for practicality using the practicality criteria in Table 2.

Table 2. Practicality Criteria (Fitriyawati et al., 2022)

Percentage %	Practicality Level
0 - 20%	Not Practical
21 - 40%	Not Very Practical
41 - 60%	Somewhat Practical
61 - 80%	Practical
81 - 100%	Very Practical

Testing the effectiveness of teaching modules using Cohen's effect size formula, which is the difference in the effect size of an independent variable that influences a dependent variable, which in this case is the application of learning modules to measure student literacy levels.

Table 3. Effectiveness Criteria (Yelpaze & Yakar, 2020)

Effect Size Value	Interpretation
0.00 – 0.20	Negligible effects
0.21 – 0.50	Small effect
0.51 – 0.80	Moderate effect
0.81 – 1.30	Big effect
> 1.30	Very big effect

Next, after assessing effectiveness, we also analyzed improvements in science literacy using the following indicators of science literacy: explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting data scientifically (Hidayati, 2019). We then analyzed the data using the effectiveness criteria in Table 3 and looked at the categories of student skills in Table 4.

Table 4. Categories of Science Literacy Levels (Asiah et al., 2019)

Value Interval	Category
90-100	Very High
75-89	High
55-74	Medium
40-54	Low
< 40	Very Low

Result and Discussion

Analysis

The research results are presented based on the five stages of the ADDIE development model, namely analysis, design, development, implementation, and evaluation. In the analysis stage, the needs of learners were identified and analyzed, including their cognitive, affective, and psychomotor knowledge backgrounds, as well as their learning experiences, both individually and in groups. The analysis results showed that the learners had never used learning modules that integrated local wisdom. Additionally, the pretest results indicated that most learners had minimal literacy, particularly in materials integrated with local cultural values. These analysis results indicated the need for varied and contextual teaching materials as additional learning resources to improve literacy. Furthermore, learning objectives were analyzed based on the analysis results to integrate local wisdom into learning by selecting ecology and biodiversity materials that are in line with the ATP and CP in the Merdeka curriculum.

Design

The learning module design consists of several stages, namely material selection, module development, and instrument development, each of which can be described as follows:

Selection of Materials

The material selected for the development of this learning module is ecology and biodiversity. This material was selected based on the researcher's analysis of one of the science subjects that is suitable for integration with the local wisdom values of the megalithic cultural heritage site in Central Sulawesi. The selection of this material is expected to increase science literacy.

Development of Learning Modules

The learning module is first composed of a cover, followed by a preface, table of contents, module usage instructions, teacher instructions, student instructions, module identity, learning activities 1–3, cultural understanding, formative tests, and worksheets. The final section includes a bibliography and author biography. The selection of colors, images, and backgrounds in the learning module is tailored to the theme and distinctive characteristics of Central Sulawesi, such as images of megalithic statues, a green batik bomba background on the pages, a yellow batik bomba footer on the pages, images of endemic animals from Central Sulawesi, and narrative questions in Worksheet 3 about biodiversity and conservation in Central Sulawesi. The content is structured to cover the following sections:

a) Learning Activities

The learning activities in this module consist of structured stages, starting with an explanation of the material, cultural understanding, ecosystems, biodiversity, and nature conservation around the megalithic cultural heritage sites of Central Sulawesi. Each learning activity includes core material designed to enhance literacy, as well as exercises that encourage students to analyze, connect scientific concepts with local wisdom, and evaluate the impact of human interaction on the environment, using a scientific approach.

b) Test formatif

The formative test consists of five short multiple-choice questions to evaluate the basic knowledge of students in each part of the learning activity.

c) LKPD

The components in the LKPD contain essay questions in the form of pictures or story questions to hone the critical thinking skills of students in each part of the learning activity.

Development

The development stage was carried out by compiling the initial learning module product (product 1), which was then validated by two experts. Validation covers aspects of content, appearance, language, and compliance with learning principles. The validation results show that the module is categorized as valid and suitable for use with minor revisions (see Table 5). The module was then revised according to the validators' suggestions, resulting in a final product (product 2) that is ready for implementation.

Table 5. Expert Validation Results for Learning Modules

	Expert Validation 1	Expert Validation 2
Total empirical score achieved	71	83
Expected total empirical score		100
Percentage (%)	71%	83%
Average		77%
Interpretation		Valid

The process of developing and validating learning modules involving expert validators is an important step in ensuring product quality. The development stage includes assessing the validity of the product before implementation. The validation results show that the module achieved an average validity score of 77%, which is considered valid.

This finding supports the view that Annam et al. (2024) which emphasizes that the development of learning materials must be based on content validity and practicality in order to effectively meet the needs and learning styles of students. Validation from experts, teachers, and students provides a strong basis for declaring that these learning modules meet comprehensive instructional development standards.

Implementation

During the implementation phase, the learning module was tested on seventh-grade students at Al-Khairaat 2 Junior High School in Palu. The learning process was carried out in accordance with classroom learning, with the addition of the learning module as reading material for students. Data collection was conducted through practicality questionnaires, skill observations, and tests to analyze the effectiveness of the learning module. Teachers and students provided positive feedback on the use of the modules (see Table 6 for teacher feedback and Table 7 for student feedback), which were deemed easy to understand, systematic, and provided opportunities for students to expand their knowledge. Additionally, the Cohen's d effect size based on pretest-posttest results of the students (Table 8) indicated the effectiveness of the modules. During implementation, students demonstrated interest and engagement with the taught material and showed improvements in literacy indicators (Table 9).

Table 6. Practicality Response Results by Teachers

	Score	Maximum Score	Percentage (%)
Principal	52		100%
Vice Principal	48		92%
Science Teacher	49	52	94%
Social Studies Teacher	44		85%
Mathematics Teacher	52		100%
Average			96%
Interpretation			Very Practical

Table 7. Practicality Response Results by Students

Indicators	Average Percentage (%)
The module material is in line with the learning objectives.	86.96
The module material is in line with the basic competencies and learning indicators.	89.49
The sequence and arrangement of material in the module is systematic and logical.	88.77
The material presented is easy for students to understand.	90.94
The material in the module motivates students to learn.	86.59
The material in the module is appropriate for the ability level and development of the students.	84.78
The language used in the module is easy to understand and does not cause ambiguity.	87.32
The module uses proper and correct Indonesian language rules.	91.67
The presentation of material is accompanied by relevant examples, illustrations, or images.	87.32
The presentation of the module is visually appealing (appearance, color, and layout).	89.13
The font type and size used in the module are proportional and easy to read.	84.78
The module provides exercises or assignments that are relevant to the material.	87.68
The instructions for using the module are clear and easy for students to follow.	92.39
The module can be used independently by students (self-instruction).	90.22
The module integrates local wisdom and can enhance students' scientific literacy and critical thinking skills.	88.04.
Average	88.41
Interpretation	Very practical

The developed learning modules were implemented in a real classroom environment for testing purposes. Practicality analysis, as evaluated by several teachers at the school (as shown in Table 6), indicates a high level of practicality, with an average score of 96%, categorized as "very practical." This suggests that the teachers involved in the pilot felt that the module was easy to use and could be effectively applied in science education in the classroom.

Practicality was also assessed through a student response questionnaire (Table 7), which evaluated various indicators related to the usefulness of the module. Overall, student ratings were consistently high across all indicators, with an average practicality score of 88%, which was also interpreted as "very practical." These findings are consistent with (Mudiartana et al., 2021) which emphasizes that a systematic approach to module development contributes to practical and effective instructional tools.

Furthermore, the effectiveness of the developed modules was analyzed using Cohen's d formula to estimate the effect size of the intervention applied through the learning modules. The effect size value was calculated based on a comparison analysis between the students' pretest and posttest results. The results of the effectiveness test analysis of the differentiated teaching modules are summarized in Table 8.

Table 8. Results of the Analysis of the Effectiveness of Learning Modules

	n	Mean	Standard Deviation
Control	35	61,571	4,161
Experiment	35	65,314	4,404
Cohen's d			0.87
Interpretation			Large Effect

The results of the calculation using Cohen's d Effect Size formula show a result of 0.87, which means that the learning module is highly effective and can be used effectively by students.

The effectiveness of a learning module is not only determined by its practicality, but also by its ability to facilitate meaningful learning. The effectiveness test was conducted to assess the module's effectiveness in improving students' learning outcomes. Effect size provides more in-depth information than mere statistical significance, as it shows the extent of the difference in learning outcomes between the group that used the module and the group that did not. The evaluation was based on pretest and posttest scores and the calculation of Cohen's d effect size between the

control group and the experimental group, each consisting of 35 students.

In the experimental group, the average pretest-posttest score was 65.314, compared to 61.571 in the control group (Table 8). The calculated effect size was 0.87, which was interpreted as a large effect, indicating that the module had a significant and effective impact on student learning outcomes.

The development of science literacy-based learning modules has a significant positive impact on improving students' science literacy skills. Modules that are designed in an integrated manner and incorporate inquiry-based or problem-based learning approaches can improve students' understanding of scientific concepts, critical thinking skills, and ability to explain scientific phenomena independently (Hidayati et al., 2023).

Table 9. Science Literacy

Indicators	Average Percentage (%)
Explain scientific phenomena (Describe the benefits of applying zoning systems in the scientific management of conservation areas.)	89
Evaluating scientific design and research (Identifying scientific issues or problems arising from the text or conservation cases in Central Sulawesi.)	76
Interpreting scientific data and evidence (Using data, facts, or observations from the text to draw conclusions about the success or challenges of conservation.)	60

Based on the results of the science literacy assessment using an instrument validated by experts and applied in the experimental class, there was a significant increase in students' science literacy levels. This progress was observed in the essay responses between the pretest and posttest, measured through the average scores and distribution across three main indicators: Explaining phenomena scientifically, Evaluating & designing investigations, Interpreting data & scientific evidence.

In the first indicator, the average literacy score was 89%, in the second indicator it reached 76%, and in the third indicator it was 60%. These results indicate that students are categorized as skilled in literacy. The table above presents the average percentage of achievement of learning indicators related to the management of conservation areas in Central Sulawesi. The first indicator, which is the ability to explain scientific phenomena by describing the benefits of applying a zoning system in conservation area management, shows the highest achievement with an average percentage of 89%. Next, the second indicator, which measures the ability to evaluate, design, and conduct scientific investigations through the identification of scientific issues or problems from conservation texts or cases, obtained an average percentage of 76%. Meanwhile, the third indicator, which focuses on the ability to interpret scientific data and evidence by using data, facts, or observation results to draw conclusions related to conservation successes or challenges, showed the lowest achievement, at 60%. These results indicate that although students are quite competent in explaining phenomena and evaluating conservation issues, there is a need for improvement in data analysis and scientific evidence interpretation skills.

Furthermore, the percentage comparison for each indicator of science literacy among students in the experimental class can be seen in the figure 2.

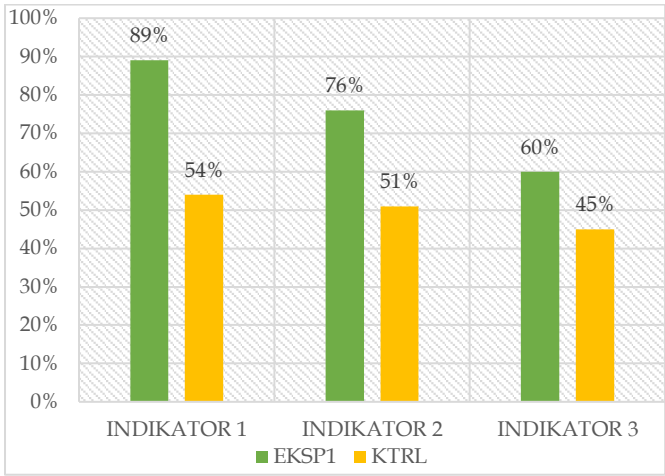

Figure 2. Graph showing the improvement in collaboration skills per indicator in the experimental class

The graph above shows a comparison of the percentage achievement of three learning indicators between the experimental group (EKSP1) and the control group (KTRL). In the first indicator, namely the ability to explain scientific phenomena, the experimental group obtained the highest percentage of 89%, while the control group only achieved 54%. The second indicator, related to the ability to evaluate, design, and conduct scientific investigations, showed an achievement of 76% in the experimental group and 51% in the control group. Meanwhile, on the third indicator, which is the ability to interpret scientific data and evidence, the experimental group achieved 60%, higher than the control group, which only reached 45%. These data indicate that across all indicators, the experimental group consistently

demonstrated higher results than the control group, with the largest achievement gap observed in the first indicator. These findings suggest a positive effect of the treatment administered to the experimental group on the improvement of students' competencies across the three measured indicators.

Based on figure 2, the performance of the control class (KTRL) on the three indicators measured shows a relatively lower achievement percentage compared to the experimental class. For Indicator 1, the control class achieved only 54%, while for Indicators 2 and 3, they achieved 51% and 45%, respectively. These percentages indicate that students in the control class have lower achievement levels in the aspects measured by these indicators. These results may reflect the effectiveness of conventional teaching methods used in the control class, which appear less optimal in improving student learning outcomes compared to the intervention or treatment provided in the experimental class. Thus, this data reinforces the importance of innovation in teaching strategies, particularly in the use of instructional materials, to significantly enhance student achievement.

Evaluation

Evaluation is the final stage in the development of learning modules that have been tested using the ADDIE model. The evaluation stage is carried out by evaluating the results of validation, responses from teachers and students through questionnaires, as well as analyzing the results of pre-tests and post-tests of students and the results of the analysis of the skills measured. The success of the learning module development is measured based on feedback obtained from teachers and students through the instruments or questionnaires that have been distributed.

The evaluation stage in the ADDIE module development model serves as a crucial final process for assessing the effectiveness and quality of the learning products that have been developed. This evaluation includes two main forms, namely formative evaluation, which is carried out continuously during the development process to provide feedback and gradual improvements, and summative evaluation, which is carried out after the product is completed to measure the overall achievement of learning objectives. The evaluation results are used as the basis for revising and refining the module to make it more valid, practical, and effective in line with the needs of learners and the learning context (Anafi et al., 2021).

Conclusion

Based on the research results, it can be concluded that the development of integrated learning modules incorporating local wisdom from Central Sulawesi has proven to be feasible, practical, and effective for use in education. The developed module is able to enhance students' understanding and scientific literacy across several indicators, thereby making learning more meaningful and culturally valuable for the students. As such, this learning module can serve as an innovative solution in supporting the implementation of education that reflects the cultural values of the local region and fostering students' sense of concern for their region through school-based learning. This study makes a significant contribution to the development of effective integrated science learning modules based on local wisdom to improve students' science literacy and critical thinking skills, but there are still several shortcomings that can be addressed in further research. This study is limited to one location and a specific sample of students, so the generalization of the results needs to be tested in a broader context and population. Future research can expand the scope by involving various levels of education and different regions to test the adaptability of the modules and their long-term effectiveness. In addition, the integration of digital technology in the module can also be developed to support more interactive and engaging learning. Broader scientific implications include an increased understanding of how the application of local wisdom values can enrich contextual science learning, while promoting sustainable cultural and environmental preservation. Thus, further research should examine the socio-cultural impact of implementing these modules and integrate qualitative evaluation methods to understand changes in students' perceptions and attitudes towards the local environment and culture.

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Author Contributions

Conceptualization, S.; methodology, S, A.S, and M; validation, N.D.N., and A.R.; formal analysis, S., investigation, S.; data curation, S..; writing—original draft preparation, S; writing—review and editing, S, A.S, and M.; All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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