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The Ijen Coffee Plantation in an Innovative Science Module to Enhance Science Literacy in Elementary School

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Abstract: This study aims to develop and analyze innovative elementary school science learning module modules based on the Ijen Arabica Coffee agricultural. This study is a research and development (R&D) study that adapts the ADDIE model. Data was analyzed through validation score, practicaly, and N-gain effectivenes. Data collection instruments include expert validation sheets, teacher and student response questionnaires, and science literacy test questions. The results of the study show that: (1) The learning module was declared to be very feasible by expert validators in terms of content, media, and language, with an average score of 90.41%; (2) The module was declared to be highly practical by teachers about 91.50% and highly interesting for students about 91.50%; (3) The module significantly improved students' science literacy, as evidenced by an increase in the average score from 50.20 to 83.45. The N-Gain analysis results showed a score of 0.67 with moderate category. The Ijen Arabica Coffee-based module is not merely supplementary material, but rather an innovative tool that can change students' perceptions of science. It was concluded that this Ijen Arabica Coffee-based science teaching module is valid, practical, and effective for use as material for training contextual science literacy in elementary schools.

Keywords: ADDIE; Ijen arabica coffe; IPA SD; Learning module; Science literacy

Introduction

Education in the 21st century requires students to master various important competencies, one of which is science literacy. Science literacy is not only related to the ability to remember scientific information, but also includes the skills of utilizing scientific knowledge, formulating questions, drawing conclusions based on evidence, and understanding the nature of science as human knowledge and investigation (Raja et al., 2025; Siregar et al., 2020). With these skills, students are expected to be able to make informed decisions on science-based issues (Wisdayana & Aththibby, 2025). The urgency of science literacy is evident from the results of the PISA international assessment, which shows that Indonesian students' achievements are still low and have never met the set standards (P. N. Putri et al., 2025; Yusmar & Fadilah, 2023).

Science Education in elementary schools plays a strategic role in shaping scientific thinking and critical thinking skills in students (Barus, 2022; Kartika, 2022). In the context of science learning in elementary schools, the development of science literacy requires teaching materials that are rich in context, relevant to students' real lives, and capable of facilitating scientific processes so that understanding is not only conceptual but also applicable (Anggrella & Sudrajat, 2024; Rukmi et al., 2025). However, in reality, science education at the elementary school level is often theoretical and not really relevant to students' real lives. This happens because most of the science material at elementary schools is just taken from books provided by the school, which means some of the students' skills, like science literacy, aren't really developed (Suparya et al., 2023). One factor that is thought to contribute to this low achievement is the science learning process in elementary schools, which

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still tends to be uncontextualized (Suparya et al., 2023). Learning is often centered on textbooks, rote memorization, and detached from the socio-cultural environment and realities that students face in their daily lives. As a result, students find it difficult to see the relevance of science to their lives, resulting in low motivation to learn and poor conceptual application skills.

One approach that can be used to address this issue is to develop teaching modules based on local potential combined with science literacy (Noviana & Julianto, 2018). Efforts to bridge the connection between science learning in schools and real phenomena in the community are made through the use of local contexts or local wisdom (Hastuti et al., 2020; Nyoman & Putu, 2024). In this case, the Ijen-Raung region (East Java) as an Ijen Arabica Coffee production area has great potential. Ijen-Raung Arabica Coffee products are known nationally and internationally for their distinctive geographical characteristics and cultivation methods. The Ijen Geopark region is an area rich in natural and cultural resources, including the Arabica coffee sector, which is a leading commodity in the region (Sari et al., 2013). Developing science modules based on local wisdom is crucial for bridging the gap between school-based science and real-world phenomena. A prime example is the Ijen-Raung region, where Ijen Arabica Coffee serves as a world-class commodity and an authentic learning resource. This agribusiness offers a rich scientific context, where cultivation, seed selection, and post-harvest processing provide practical illustrations of biology, chemistry, and physics. By integrating these local agricultural practices into the curriculum, abstract science concepts like ecosystems, soil nutrients, and plant physiology become tangible, contextual, and relevant for elementary students (Dwita et al., 2024).

However, a number of studies show that the development of science literacy based modules or teaching materials at the elementary school level is still limited, especially those that relate to the local agricultural context and regional superior products (Wulandari & Hardhienata, 2025). For example, research shows that the development of science literacy-based modules in elementary schools can improve science learning outcomes, but there is still little research that specifically links this to the local agricultural context. Furthermore, although many studies have examined aspects of science literacy in elementary schools, there are still obstacles such as teachers' inadequate understanding of science literacy (Wu et al., 2022; Zhang et al., 2024), limited learning resources, and materials that do not explicitly integrate the real-life context of students. While previous research has explored science literacy broadly, this study fills a critical gap by specifically integrating the Ijen Arabica Coffee agribusiness a globally recognized local commodity into an elementary science module to transform abstract concepts into contextually relevant learning experiences

Although the urgency of contextual learning based on local wisdom has been widely recognized, there is a significant gap in the literature. The first gap is the lack of utilization of the specific potential of Ijen Arabica coffee agriculture as a context for science learning at the elementary school level. Existing research may focus on coffee from an economic or agrotechnological perspective. However, its implementation as formal science teaching material in elementary schools is still very limited. The next gap is the lack of development of innovative teaching materials, such as teaching modules that systematically integrate the study of Ijen coffee farming for the specific purpose of improving science literacy. Much research focuses on the development of science modules based on local wisdom in general (Akhsan & Wiyono, 2025; Anggelya et al., 2025). However, there has been no research specifically designed to develop, implement, and test the effectiveness of elementary school science teaching modules centered on the phenomenon of Arabica coffee farming in Ijen to train science literacy components.

Based on the background and research gaps that have been identified, this study has the main objective of developing and analyzing innovative elementary school science teaching modules based on the study of Ijen Arabica coffee farming. These modules are specifically designed to be valid, practical, and effective contextual learning tools that support the strengthening of elementary school students' science literacy. The novelty of this research lies in the deep integration of specific local wisdom (Ijen Coffee) into the structure of science teaching modules oriented towards improving science literacy competencies.

Method

The research used is Research and Development, using the ADDIE development model. The ADDIE model was utilized for its established capability in generating high-quality science e-modules that consistently meet standards of validity, practicality, and effectiveness, the product development procedure in accordance with the ADDIE steps shown in Figure 1.

This study, conducted during the even semester of the 2025/2026 academic year, utilized a case study approach involving fifth-grade students and local coffee farmers in Ijen as primary informants. To ensure the developed module addressed specific educational needs, a preliminary study was performed at SDN Dabasah 3 Bondowoso through targeted interviews and observations, an essential phase for gathering

foundational research data (Spatioti et al., 2022). Comprehensive data collection employed validation sheets, interviews, objective tests, and questionnaires to evaluate the module's quality. Specifically, the analysis stage focused on identifying existing pedagogical gaps, while structured questionnaires were used to measure the practicality of the teaching materials in terms of content accuracy, design quality, and media suitability.

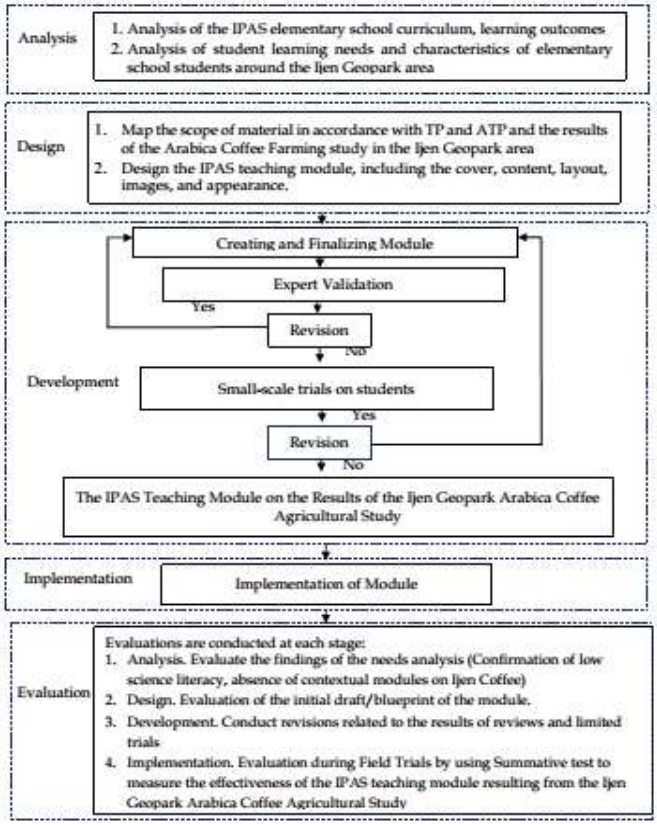

Figure 1. ADDIE process

The data analysis technique used in this study was descriptive statistical analysis. The data analysis stages included validation, effectiveness testing, and practicality testing. Validation was a form of verification or testing of product content suitability. The validation results were obtained from expert validators in the fields of media, language, and material. The scores given were determined based on the average value of each validity using the following validity formula:

$$\text{Validation} = \frac{\text{Real score}}{\text{Maximum score}} \times 100 \quad (1)$$

Table 1. Validity Criteria

Score criteria	Product Feasibility Category
$80 \leq V \leq 100$	Very Feasible
$60 \leq V < 80$	Feasible
$40 \leq V < 60$	Quite Feasible
$20 \leq V < 40$	Less Feasible
$0 \leq V < 20$	Very Less Feasible

The effectiveness of product development can be measured through learning outcome analysis. An independent sample t-test was conducted to identify differences in sample means. This test was used because the research model employed a pre-test and post-test.

$$\text{n} - \text{gain} = \frac{\text{Postest Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}} \quad (2)$$

Table 2. N-gain Interpretation

Score criteria	Category
$g > 0.70$	High
$0.3 \leq g \leq 0.7$	Middle
$g < 0.3$	Low

Student feedback is needed to measure the practicality of product development. Questionnaires are a tool for obtaining student feedback. A product can be considered practical if it receives ≥ 50% positive feedback, which can be calculated using the following formula:

$$\text{P} = \frac{\text{F}}{\text{N}} \times 100\% \quad (3)$$

Description:
P = Percentage of student responses
F = Students who gave positive responses
N = Total number of students

Table 3. Student Respond Criteria

Student Response (%)	Criteria
81 – 100	Very good
61 – 80	Good
41 – 60	Quite good
21 – 40	Unsatisfactory
0 – 20	Very Unsatisfactory

Result and Discussion

Results

The following are the results of the ADDIE model stages that have been completed based on the analysis, design, development, implementation, and evaluation stages. The analysis process carried out in this study includes three different stages, namely (i) documents, (ii) locations, and (iii) people (Lestari et al., 2021). Paper is a written data source that can be used as a reference. The written data source used in the analysis stage is teaching materials used in schools. Places are data sources in the form of locations and infrastructure that can be used as data sources. The researchers chose SDN Dabasah 3 Bondowoso as the research location. People are human data sources who can provide data through verbal answers (Timalsina, 2021).

Analysis

The analysis stage focuses on identifying problems and needs in the field (Ade Rahayu, 2025; Waruwu, 2024). Three main analyses were conducted: an analysis of teacher and student needs, a curriculum analysis, and an analysis of local potential. The results of the teacher needs analysis explained that teachers had never used specific teaching modules that integrated Ijen Arabica coffee-based science literacy. In addition, the learning process was dominated by lectures and textbooks. The implementation of science literacy in reading and formative assessments was still minimally developed, resulting in declining learning outcomes.

The student analysis included a preliminary test of 28 students, which showed an average score of 50.20, far below the minimum passing grade. Apart from the preliminary test, interviews with students revealed that they enjoyed interactive teaching books. Students also had minimal understanding of the connection between the material and local wisdom, resulting in a very poor understanding of the scientific process involved in processing Ijen Arabica coffee. The curriculum analysis found that material related to the local potential of Ijen coffee farming is included in phase C of grades V-VI in the science subjects of Changes in the Form of Substances, Ecosystems, Food Chains, and Properties of Objects with the agribusiness process of Ijen Arabica Coffee. The material studied is divided into three modules, namely the anatomy of Ijen Arabica coffee, the coffee processing process, and coffee cultivation.

Design

Based on the analysis results, a preliminary draft of the product was designed. The focus of this stage was to formulate the structure of the modules and research instruments. The result of this stage was a draft prototype of teaching modules with the following characteristics.

Figure 2. Teaching module design

Develop

This stage focuses on product validation by experts to measure the validity level of the module. Validation is carried out by three experts (science subject matter expert, learning media expert, and language expert).

Table 4. Validity Result

Validator	Aspects Assessed	Average Score	Criteria
Expert of subject matter	Content material suitability	91.25	Very Feasible
Expert of Media	Design suitability	87.50	Very Feasible
Expert of Language	Language suitability	92.50	Very Feasible
Average		90.41	Very Feasible

Based on the table above, the validity results from subject matter experts, media, language, and practitioners were very feasible. The validity of the three modules was obtained due to the integration of the local potential of Ijen Bondowoso coffee into elementary school science material. In accordance with Ifan's research (Aji & Pujiastuti, 2022) related to the development of science books, the results of product assessments aimed at subject matter experts, media experts, and language experts were valid.

Implementation

The implementation stage involves field testing the product to measure its practicality and effectiveness. The following are the results of practicality and effectiveness.

Table 5. Practicality Result

Aspects Assessed	Average Score	Criteria
Teacher		
Easy-to-use modules	92.50%	Very good
Appropriate with character of students	87.00%	Good
Clarity of modules guiding teachers	95.00%	Very good
Average of practicality	91.50%	Very good
Students		
Design appeal	94.00%	Very good
Clarity of material	88.50%	Very good
Motivation to learn after using the module	92.00%	Very good
Average of interesting	91.50%	Very good

Table 6. Effectiveness Result

Statictic	Pre-test	Post-test
Number of students	28	28
Average score	50.20	83.45
Highest score	65	95
Lowest score	35	70
Standar deviation	8.15	6.70

The n-gain score obtained was 0.667, which falls into the "Moderate" category (based on Hake's criteria).

Discussion

Innovative science education at the elementary school level should be directed toward building scientific literacy, namely the ability to understand natural phenomena, use scientific knowledge to make decisions, and evaluate the impact of science on life (OECD, 2019). However, in practice, science education in many schools is still textual and abstract, making it difficult for students to relate scientific concepts to real life. The innovation of the Ijen Arabica Coffee Agricultural Science Literacy teaching module shows that the context of local coffee farming can be an authentic learning space that connects science concepts to students' daily experiences (Fatkhiyani & Dewi, 2020). Local wisdom-based learning can improve students' conceptual understanding, motivation, and scientific attitudes (Irhasyuarna et al., 2022; Sya'ban & Wilujeng, 2016; Wilujeng et al., 2019).

It is in this context that research on Science Literacy in the Study of Ijen Arabica Coffee Farming in Innovative Elementary School Science Teaching Modules becomes relevant. This study attempts to present science learning that not only emphasizes cognitive aspects but also connects science with the local cultural environment of students (Fakoyede et al., 2025; Septina et al., 2025), especially the culture of Arabica coffee farming in Ijen. Coffee farming is not just a livelihood for the people of Bondowoso, but also a social and cultural identity that has been passed down from generation to generation. By introducing the context of science into the classroom, learning is not only academic, but also emotionally, socially, and culturally meaningful for students (Dwi et al., 2025; Japa et al., 2021).

The ecological conditions of the Ijen region are those of a volcanic mountainous area with mineral-rich andosol soil, cool temperatures, stable humidity, and sunlight intensity that supports the growth of Arabica coffee plants. These ecological conditions are highly relevant to the science curriculum for grades 4 and 5, such as the interaction of living things with their environment, adaptation, the process of photosynthesis, the water cycle, and the role of solar energy in life. Through the coffee farming-based teaching module, students no longer learn about photosynthesis only from pictures in books, but can directly observe how coffee leaves capture light and how soil conditions affect plant growth. At this point, learning becomes concrete: students learn through objects, processes, and environments that they are truly familiar with (Nana Hendracita, 2021).

Ijen Arabica coffee is Bondowoso's leading commodity, grown on the volcanic andosol soil of the Ijen slopes. These ecological conditions are relevant to science subjects such as the interaction of living things with the environment, adaptation, photosynthesis, and the water cycle. By using the local environment as a natural laboratory, science learning becomes contextual (Japa et al., 2021). This is in line with the principle of contextual teaching and learning, which emphasizes the relationship between subject matter and students' real-life experiences (Dewi & Primayana, 2019; Glynn & Winter, 2004). Arabica coffee farming in Ijen was chosen because it has very distinctive ecological, geographical, and social characteristics. The slopes of Mount Ijen are a volcanic area with mineral-rich andosol soil, relatively stable temperatures, and humidity that supports the development of high-quality Arabica coffee (Basuki et al., 2021; Sari et al., 2013). he lengthy process of coffee processing, from seedling, maintenance, harvesting, fermentation, drying, to roasting, involves many IPA concepts such as the interaction of living things with the environment, photosynthesis, adaptation, temperature and heat, the biological processes of microorganisms, and the physical and chemical properties of materials.

The main findings of this study indicate that the innovation of science teaching modules based on the study of Arabica coffee farming in Ijen is valid, practical, and significantly effective in improving the science literacy of elementary school students. This improvement is evidenced by an n-gain score of 0.67 (category "Moderate"), which confirms a very significant difference between students' initial (pre-test) and final (post-test) abilities. The effectiveness of this module can be explained through several key factors that are interrelated in applying the principles of Contextual Teaching and Learning (CTL). The results of the analysis confirm that there is a gap among students living in the agricultural environment of Ijen Coffee but who are scientifically disconnected from this phenomenon.

This module systematically bridges that gap. By raising real phenomena, it is no longer presented as an abstract concept that must be memorized(Akhsan & Wiyono, 2025). This is in line with Ausubel's meaningful learning theory, which states that learning becomes permanent only if new information can be linked to the cognitive structure (knowledge/experience) that students already have (Bryce & Blown, 2024; Sexton, 2025). When students see the direct relevance between

science in the classroom and their parents' professions or their surrounding environment, their intrinsic motivation and conceptual understanding increase dramatically (Kusuma, 2025). This learning approach is in line with the principles of contextual teaching and learning, which is learning that connects subject matter with students' real-life experiences so that knowledge becomes meaningful and can be used in their lives (Glynn & Winter, 2004). Additionally, this learning approach supports the Discovery Learning approach, which places students as discoverers of meaning through the processes of observation, analysis, and reflection (Ozdem-Yilmaz & Bilican, 2025).

The effectiveness of the teaching module received an n-Gain score of 0.67 in the moderate category. This indicates that the developed module has competitive effectiveness. The effect of using the Ijen Arabica coffee culture-based module is not only seen in improved academic learning outcomes but also in increased learning motivation (Nasir et al., 2023; Sahronih et al., 2019; Susanto et al., 2025). Students feel proud because what they learn at school is directly related to the lives of their families and the communities around them. This is in line with the opinion (Septarinjani et al., 2025) that local wisdom-based learning can strengthen cultural identity and increase students' emotional involvement in the learning process. In the developed module, learning activities are designed in the form of contextual stories about the lives of coffee farmers, followed by direct observation, simple experiments, and reflective discussions.

The validation results cannot be separated from the quality of the product tested at the Development and Implementation stages. The final validation results scored 90.41 with very feasible, indicating that this module is suitable for use as a teaching module (Hardiansyah et al., 2025). Practicality scored 91.50% in the very good category. According to (Firanti & Kurniawati, 2025), module's practicality test conducted by teachers and students amounted to 92.92% and 87.45% with a very practical category. Practicality is the key to innovation sustainability. This module was successfully designed to be easily implemented by teachers in real time in the classroom, rather than as an additional administrative burden. The context of Ijen Coffee has been proven to trigger students' curiosity (Jirout, 2020), which is a major factor in inquiry-based science learning. The emotional and visual connection (module design) to the local context successfully maintained student engagement during the learning process, which correlates directly with better cognitive learning outcomes.

Students learn to understand science concepts gradually through direct observation, contextual discussion, and explanations of phenomena they encounter in everyday life (Raja et al., 2025). The relevance of science teaching modules to science literacy can improve literacy by reinforcing science concepts, training scientific process skills, and encouraging reasoning and problem solving (Suryanti et al., 2020). Local wisdom-based learning in the science teaching module makes students appreciate the profession of coffee farmers as an important part of regional identity. Learning not only shapes intellectual abilities, but also ecological awareness and mutual cooperation as cultural values of the Ijen community. From a scientific perspective, learning based on direct observation like this fosters curiosity, accuracy, data recording skills, and the ability to draw conclusions based on evidence. These competencies are part of the scientific process skills, which are at the core of science learning (A. N. Putri & Muhartati, 2019). In this study, students not only received knowledge but also practiced the scientific process as scientists conduct investigations.

The integration of coffee farming into learning has strong social implications, especially in areas where the community's economy depends on the agro-industrial culture. This module also supports the development of the Pancasila Student Profile, particularly in the elements of Critical Thinking, Global Diversity, and Mutual Cooperation (Irvan & Mustadi, 2021), as students learn to appreciate local culture while understanding that Ijen coffee products are also known internationally. This means that learning based on local wisdom also broadens students' global horizons, rather than confining them to their own region. Thus, science learning not only produces academic abilities, but also local economic awareness and social entrepreneurship that are relevant to the development of 21st century education.

Conclusion

The elementary school science teaching module based on the study of Arabica coffee farming in Ijen has been successfully developed through the ADDIE stages and declared very feasible based on assessments by subject matter experts, media experts, and language experts, with a total average score of 90.41. The developed teaching module meets quality criteria in terms of field implementation, namely it was declared very good by teachers with averaging 91.50% and very good for students 91.50%. Teaching module has been proven to be significantly effective in improving students' science literacy. This is evidenced by an increase in the average pre-test score (50.20) to the post-test score (83.45), with n-gain score is 0.67 in the moderate category. These findings confirm that teaching material innovations that integrate specific local wisdom (Ijen Coffee agribusiness) as a learning context have

been proven to bridge abstract science concepts with students' realities, making learning more meaningful and positively impacting the achievement of science literacy competencies. Future research is recommended to explore the integration of interactive digital technologies, such as augmented reality, to further deepen science literacy local scientific phenomena.

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