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Journal of General Education and HumanitiesVol. 5, No. 3, June 2026, pp. 4253 – 4274, <https://doi.org/10.58421/gehu.v5i3.1627>

ISSN 2963-7147

4253

Development of Ethnoscience-Based Digital Student Worksheets to Improve Scientific Literacy and Critical Thinking Skills of Elementary School Students**Purnama Indra¹, Antonius Totok Priyadi², Ricka Tesi Muskania³**^{1,2,3}Faculty of Teacher Training and Education, Tanjungpura University, Pontianak, Indonesia**Article Info****Article history:**

Received 2026-05-17

Revised 2026-06-25

Accepted 2026-06-30

Keywords:

Critical thinking

Digital LKPD

Elementary school science and social studies (IPAS)

Ethnoscience

Scientific literacy

ABSTRACT

Science and Social Studies (IPAS) learning in elementary schools still faces challenges in strengthening students' scientific literacy and critical thinking skills because the learning process tends to be textual, less contextual, and has not optimally integrated local culture and digital technology. This study aims to develop an ethnoscience-based digital student worksheet (LKPD) that is valid, practical, and effective in improving elementary school students' scientific literacy and critical thinking skills. The research employed a Research and Development (R&D) method using the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages. The research subjects involved 28 elementary school students. Data were collected through observation, interviews, questionnaires, tests, and documentation, and then analyzed using descriptive statistics and the N-gain test. The results showed that the ethnoscience-based digital LKPD obtained an average validation score of 91.1%, categorized as highly valid. The implementation of the product demonstrated an improvement in scientific literacy with an N-gain score of 0.71 and critical thinking skills with an N-gain score of 0.69. The integration of local culture, interactive multimedia, and project-based learning proved to enhance students' engagement, scientific reasoning, and problem-solving abilities. These findings confirm that the ethnoscience-based digital LKPD is effective in supporting contextual IPAS learning and 21st-century learning in elementary schools.

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Email: antonius.totok.priyadi@fkip.untan.ac.id**1. INTRODUCTION**

Ethnoscience in elementary school learning is regarded as an approach capable of connecting scientific concepts with students' local culture. This approach positions culture not only as a context but also as a source of knowledge that builds meaningful, reflective, and contextual learning experiences. In science and social studies learning (IPAS),

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ethnoscience helps students understand natural phenomena through cultural practices closely related to their daily lives, thereby enhancing learning engagement, conceptual understanding, and students' scientific literacy [1], [2]. In addition, this approach strengthens students' character, cultural identity, and ecological awareness, making learning more humanistic and contextual [3], [4].

The urgency of ethnoscience-based learning has become increasingly important because elementary school students' scientific literacy still faces various challenges. Scientific literacy is not only related to mastering concepts but also to the ability to think critically, understand scientific phenomena, make rational decisions, and solve evidence-based problems [5]. However, science and social studies learning (IPAS) remains predominantly textual and memorization-oriented, thus providing limited support for higher-order thinking skills and students' scientific reasoning [6], [7]. This condition is exacerbated by the underutilization of local culture as a contextual learning resource, even though traditional community practices are closely related to scientific concepts. Research indicates that ethnoscience-based learning and instructional materials can improve scientific literacy, environmental awareness, and students' understanding of the nature of science through contextual activities [8], [9].

On the other hand, elementary school students' critical thinking skills also remain a challenge because science and social studies learning (IPAS) is often conducted in a one-way manner and provides limited opportunities for scientific exploration. As a result, students tend to receive information rather than construct knowledge through inquiry and problem-solving, causing scientific inquiry and reflective thinking to develop less optimally [10], [11]. Therefore, learning innovation is needed to integrate local culture, scientific activities, and digital technology in a comprehensive manner.

The development of educational technology provides opportunities through the use of digital student worksheets (LKPD) that are more interactive, flexible, visual, and collaborative. Digital LKPDs are capable of integrating multimedia, videos, simulations, augmented reality, and project-based activities, thereby strengthening students' learning experiences [12], [13]. The use of digital technology in science and social studies learning (IPAS) has also been proven to increase learning motivation, student engagement, and understanding of abstract concepts in a more concrete manner [14]. In the implementation of the Merdeka Curriculum, ethnoscience-based digital LKPDs become strategic media for supporting contextual learning, differentiation, deep learning, and 21st-century competencies. Research shows that e-modules based on computational thinking and differentiated learning are able to significantly improve students' scientific literacy, while the integration of augmented reality can strengthen students' ecoliteracy and conceptual understanding [15], [16].

Nevertheless, research on ethnoscience-based digital LKPDs to improve elementary school students' scientific literacy and critical thinking skills is still limited. Most previous studies have focused more on multimedia or general learning models without integrating local culture, scientific literacy, critical thinking, and digital technology comprehensively [17], [18]. Therefore, the development of ethnoscience-based digital LKPDs is important to create contextual, interactive, and meaningful learning experiences. This study is directed

toward the development of ethnosience-based digital LKPDs that are valid, practical, and effective in improving elementary school students' scientific literacy and critical thinking skills in science and social studies learning (IPAS), while simultaneously strengthening the integration of culture, technology, and humanistic as well as sustainable science learning.

2. METHOD

This study employed the Research and Development (R&D) method using the ADDIE framework (Analysis, Design, Development, Implementation, Evaluation) to develop an ethnosience-based digital student worksheet (LKPD) aimed at improving elementary school students' scientific literacy and critical thinking skills. The selection of the ADDIE model was based on its systematic, flexible, and adaptive characteristics in developing digital teaching materials that meet the needs of 21st-century learning and are relevant to the implementation of the Merdeka Curriculum.

The analysis stage was conducted through observations, interviews, questionnaires, and documentation studies to identify students' needs, the characteristics of IPAS learning, local cultural potential, and problems related to scientific literacy in elementary schools. The design stage included the development of the digital LKPD structure, storyboard creation, integration of ethnosience, critical thinking activities, and interactive multimedia based on deep learning and TPACK approaches.

Furthermore, the development stage involved product preparation, validation by material, media, and language experts, as well as product revision based on validators' feedback. In the implementation stage, the digital LKPD was tested in IPAS learning at elementary schools through project-based learning and local cultural exploration to measure its practicality as well as students' and teachers' responses. The evaluation stage was conducted both formatively and summatively through the analysis of validity, practicality, effectiveness, improvements in scientific literacy, and students' critical thinking skills using descriptive analysis and N-gain analysis.

3. RESULTS AND DISCUSSION

The identification of problems in IPAS learning at elementary schools in Pontianak City was conducted through observations, teacher interviews, analysis of the Merdeka Curriculum documents, and questionnaires on the needs of students and teachers, focusing on scientific literacy, critical thinking, digital media, local culture integration, and contextual learning. The analysis results showed that learning activities were still dominated by textual and teacher-centered approaches, so student involvement in exploratory, investigative, and reflective activities had not been optimal in supporting scientific literacy and critical thinking skills. In addition, teachers still faced limitations in developing innovative technology-based teaching materials and ethnosience approaches aligned with the characteristics of the Merdeka Curriculum. Therefore, the development of ethnosience-based digital student worksheets (LKPD) integrating local culture, interactive multimedia, and project-based learning is needed to make IPAS learning more contextual and meaningful.

Table 1. Identification of Problems and Needs in IPAS Learning

| Identification Focus | Main Findings | Indicators | Data Sources |
|--------------------------|---|---|----------------------------------|
| IPAS Learning | Learning is still textual and teacher-centered | Low student exploration and investigation | Observation, interviews |
| Scientific Literacy | Scientific literacy has not been optimal | Difficulty connecting concepts with real-life situations | Pre-test, observation |
| Critical Thinking | Analytical and problem-solving skills are still low | Limited HOTS activities | Observation, student assignments |
| Learning Media | Interactive digital media are not yet optimal | Learning still relies on textbooks | Interviews, documentation |
| Ethnoscience Integration | Local culture has not been utilized in IPAS | Learning is less contextual | Observation, document study |
| Teacher Needs | Teachers require innovative digital LKPD | Interactive and contextual teaching materials are still limited | Questionnaires, interviews |
| Student Needs | Students prefer visual and interactive learning | High interest in digital media | Student questionnaires |
| IPAS Learning Outcomes | Learning outcomes emphasize scientific literacy and real-life contexts | Deep learning and project activities are not yet optimal | Document analysis |
| Merdeka Curriculum | Differentiated learning and project implementation still face obstacles | Adaptation of teaching materials is not yet optimal | Interviews, documentation |

The identification results indicate that IPAS learning in elementary schools still faces challenges in developing students' scientific literacy and critical thinking skills. Learning activities still focus on content delivery and have not optimally provided exploratory experiences based on real-life contexts. The integration of local culture as a source of ethnoscience is also still limited, causing IPAS concepts to remain insufficiently connected to students' daily lives. Furthermore, teachers still experience limitations in developing digital teaching materials that align with the characteristics of the Merdeka Curriculum, particularly in integrating technology, differentiated learning, and critical thinking activities. These conditions indicate the need for developing ethnoscience-based digital LKPD that are interactive, contextual, and rooted in local culture to support students' scientific literacy and critical thinking skills.

The identification of scientific literacy and critical thinking skills through diagnostic tests, observations, assignment analysis, and interviews revealed that most students were still at the basic level, particularly in aspects of data interpretation, scientific reasoning, and contextual problem-solving. Learning activities that are still predominantly theoretical have caused students to be less accustomed to conducting independent scientific exploration, investigation, and reflection. Therefore, innovations in ethnoscience- and digital technology-based learning are needed to increase student engagement in IPAS learning in a more contextual, interactive, and meaningful manner.

Table 2. Identification of Scientific Literacy and Critical Thinking Levels in IPAS Learning

| Identification Aspect | Main Findings | Indicators | Techniques |
|-----------------------------------|---|---|-------------------------------|
| Understanding of Science Concepts | Understanding is still partial and memorization-based | Difficulty explaining scientific phenomena | Diagnostic tests, observation |
| Scientific Reasoning | Scientific reasoning is still low | Unable to draw conclusions based on evidence | Essay tests, interviews |
| Contextual Scientific Literacy | IPAS concepts are difficult to relate to real life | Low application of concepts | Learning observation |
| Information Analysis | Analysis of scientific information is still limited | Difficulty distinguishing facts from opinions | Critical thinking tests |
| Problem Solving | Problem-solving skills are not yet optimal | Difficulty solving contextual problems | Assignment analysis |
| Scientific Argumentation | Logical argumentation has not yet developed | Answers are still descriptive | Discussions, interviews |
| Exploratory Activities | Investigative involvement is still low | Passive and teacher-centered learning | Classroom observation |
| Local Culture Integration | Local culture has not been utilized | Learning is less contextual | Documentation study |
| Digital Media | Interactive media are not yet optimal | Students are more interested in visual learning | Student questionnaires |
| Learning Needs | Digital ethnosience-based IPAS learning is needed | Need for exploratory and contextual activities | Questionnaires, interviews |

The identification results indicate that elementary school students' scientific literacy and critical thinking skills still need to be strengthened, particularly in the aspects of scientific reasoning, information analysis, problem-solving, and scientific argumentation. Most students still understand IPAS concepts theoretically and are not yet able to relate them to real-life phenomena. Learning activities that are still dominated by teacher-centered approaches have caused exploration and scientific investigation activities to remain underdeveloped. In addition, the utilization of local culture as a source of ethnosience and the use of interactive digital media in IPAS learning are still limited. These conditions demonstrate the need for the development of ethnosience-based digital LKPD that are contextual, exploratory, and technology-based to improve students' scientific literacy and critical thinking skills.

The analysis of local cultural potential through observations, interviews, questionnaires, and documentation studies showed that local culture has great potential as a source of ethnosience that can be integrated into contextual and real-life experience-based learning activities. Furthermore, students demonstrated a high interest in visual and interactive digital media, while teachers required digital LKPD that support differentiated learning, critical thinking, and scientific literacy in accordance with the characteristics of 21st-century learning.

Table 3. Analysis of the Potential of Ethnoscience Sources in IPAS Learning

| Analysis Focus | Main Findings | Indicators | Data |
|--------------------------|---|---|----------------------------|
| Local culture | Potential as a source of ethnoscience | Environmental and conservation practices relevant to IPAS | Observation, interviews |
| Ethnoscience integration | Not yet optimally implemented | Learning materials are still less contextual | Documentation, observation |
| Student characteristics | Students prefer visual-interactive media | High interest in digital multimedia | Student questionnaires |
| Digital media | Teachers need interactive worksheets | The need for exploration-based multimedia | Interviews, questionnaires |
| 21st-century learning | Strengthening 4C skills and scientific literacy is needed | Critical thinking and collaboration are not yet optimal | Observation |
| Merdeka Curriculum | Contextual teaching materials are still limited | Project-based learning has not been optimally implemented | Interviews, documentation |
| Learning technology | Digital media are still minimally used | Learning is predominantly book-based | Classroom observation |
| Scientific literacy | Scientific reasoning is still low | Problem-solving skills have not yet developed | Pre-test, observation |
| Product needs | Digital ethnoscience worksheets are needed | Must be interactive and contextual | Questionnaires, interviews |
| Development basis | Data support product development | In accordance with the actual needs of schools | Data triangulation |

The analysis results indicate that local culture has great potential as a source of ethnoscience in IPAS learning because it is directly related to students' daily lives. However, this potential has not been optimally utilized, resulting in learning that still tends to be abstract and less contextual. Observations, interviews, and questionnaires revealed that students are more interested in interactive multimedia-based learning, while teachers require digital teaching materials that support 21st-century learning, scientific literacy, and critical thinking in line with the Merdeka Curriculum. In addition, the implementation of differentiated and project-based learning still requires innovative teaching materials. These findings form the basis for the development of digital ethnoscience-based worksheets to create IPAS learning that is contextual, interactive, and relevant to students' needs in the digital era.

The conceptual design of digital ethnoscience-based worksheets was developed based on an analysis of students' needs, teachers' needs, IPAS characteristics, the learning outcomes of the Merdeka Curriculum, and the potential of local culture. The worksheets were designed by integrating scientific literacy, critical thinking, local culture, and digital technology through culture-based phenomena, exploratory project activities, interactive multimedia, and assessments that support students' scientific reasoning and problem-solving skills. This design also refers to the principles of deep learning, differentiated learning, and the TPACK approach to create meaningful learning experiences in accordance with 21st-century characteristics. The integration of ethnoscience helps students understand IPAS

concepts through cultural and environmental contexts, making learning more authentic and reflective.

Table 4. Conceptual Design of IPAS Learning Worksheets

| Component | Core Design | Purpose | Integration |
|------------------------|---|---|--------------------------|
| Worksheet structure | Orientation, exploration, project, reflection, evaluation | Facilitate the learning process | Contextual deep learning |
| Ethnoscience | Local culture-based IPAS materials | Connect science with real-life situations | Local wisdom |
| Scientific literacy | Observation, investigation, scientific reasoning | Improve scientific literacy | Scientific literacy |
| Critical thinking | Analysis of contextual problems | Develop HOTS and problem-solving skills | Critical thinking |
| Multimedia | Videos, animations, images, QR codes | Increase student engagement | Digital learning |
| Project-based learning | Environment-based ethnoscience projects | Build authentic learning experiences | PjBL |
| Differentiation | Variation in activities and media | Adjust to students' needs | Differentiated learning |
| Digital technology | Flexible digital-based worksheets | Support 21st-century learning | TPACK & Society 5.0 |
| Evaluation | Assessment of literacy and critical thinking | Measure learning effectiveness | Assessment for learning |
| Visual design | Simple and interactive appearance | Increase learning motivation | User-friendly |

The results of the conceptual design indicate that the digital ethnoscience-based worksheets were developed as IPAS learning tools that integrate local culture, scientific literacy, critical thinking, and digital technology in a comprehensive manner. The worksheet structure includes observation, exploration, ethnoscience projects, reflection, and evaluation activities to support contextual and meaningful learning. Interactive multimedia such as videos, animations, images, and QR codes are utilized to enhance student engagement. In addition, the worksheets emphasize scientific reasoning, problem-solving, and project-based learning so that students can develop critical thinking skills through authentic learning experiences based on local culture. These findings demonstrate that digital ethnoscience-based worksheets have the potential to support the implementation of the Merdeka Curriculum and 21st-century learning in a more interactive and innovative way.

The identification of material structure, learning objectives, and indicators of scientific literacy and critical thinking was conducted through an analysis of the IPAS learning outcomes in the Merdeka Curriculum, elementary school students' characteristics, the needs of 21st-century learning, and the integration of ethnoscience based on local culture. The materials were designed contextually by linking local cultural phenomena with scientific concepts. The learning objectives focus on the development of scientific literacy, scientific reasoning, problem-solving, and critical thinking through observation, investigation, reflection, and ethnoscience project activities. Furthermore, the learning indicators were systematically integrated into the aspects of knowledge, skills, and scientific attitudes in accordance with the principles of deep learning and the Merdeka Curriculum. This

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<https://doi.org/10.58421/gehu.v5i3.1627>

development also considers interactive digital learning to enhance student engagement and higher-order thinking skills in IPAS learning.

Table 5. Structural Components of the Ethnoscience-Based LKPD for IPAS Learning

| Component | Main Findings | Indicators | Integration |
|-------------------------|--|--|------------------------------------|
| IPAS material structure | Materials are based on local culture and environment | Contextual and applicable | Ethnoscience & contextual learning |
| Learning materials | Include observation and cultural exploration | Real learning experiences | Project-based learning |
| Learning objectives | Develop scientific literacy and critical thinking | Scientific reasoning & problem solving | Scientific literacy |
| IPAS objectives | Connect concepts with real-life situations | Contextual understanding | Contextual learning |
| Scientific literacy | Identify and explain scientific phenomena | Observation & data interpretation | Inquiry learning |
| Scientific literacy | Use scientific evidence | Scientific argumentation | Evidence-based learning |
| Critical thinking | Analyze problems and solutions | Critical reasoning | HOTS |
| Critical thinking | Evaluate information and arguments | Reflective thinking | Problem solving |
| Digital integration | Supported by multimedia and digital LKPD | Visual-interactive learning | TPACK & digital learning |
| Evaluation | Assessment of literacy and critical thinking | Tests, observation, projects | Authentic assessment |

The identification results indicate that IPAS materials need to be arranged contextually by integrating local culture and ethnoscience activities so that students can more easily understand scientific concepts in everyday life. The learning objectives are focused on developing scientific literacy, scientific reasoning, problem solving, and critical thinking through observation, investigation, projects, and scientific reflection. The learning indicators are designed to measure students' abilities in analyzing scientific phenomena, using evidence, evaluating problems, and constructing logical arguments. These findings emphasize the importance of integrating ethnoscience and digital technology into IPAS learning in accordance with the characteristics of the Merdeka Curriculum.

The preparation of the flowchart and storyboard for the ethnoscience-based digital LKPD was conducted based on IPAS learning needs, elementary school students' characteristics, local culture, and 21st-century learning. The flowchart illustrates the learning process starting from orientation, exploration, ethnoscience projects, reflection, and evaluation, while the storyboard contains page designs, interactive multimedia, navigation, as well as scientific literacy and critical thinking activities. The LKPD display was designed to be simple and user-friendly with support from images, videos, animations, QR codes, and digital links to increase student engagement. The integration of local culture and ethnoscience projects helps connect IPAS concepts with students' real-life experiences.

| COMPONENT | KEY RESULT | PURPOSE | INTEGRATION |
|---------------------|---|--------------------------------|--------------------------|
| Flowchart LKPD | Systematic learning flow | Support interactive learning | Deep learning & PjBL |
| Storyboard | Contains page design, content, and activities | Guide digital development | Multimedia learning |
| Interface | Simple and child-friendly appearance | Increase learning motivation | User-friendly learning |
| Digital Navigation | Easy and flexible access | Facilitate use of LKPD | Digital learning |
| Multimedia | Videos, animations, audio, images, QR code | Increase student engagement | Interactive multimedia |
| Local Culture | Content based on local phenomena | Connect science with real life | Etnosains & local wisdom |
| Project Activities | Environmental and cultural exploration | Develop problem solving | Project-based learning |
| Contextual Learning | Activities based on real-life experiences | Build meaningful learning | Contextual learning |
| Science Literacy | Includes observation and investigation | Develop scientific literacy | Inquiry learning |
| Critical Thinking | Analysis and reflection tasks | Develop HOTS | Critical thinking |

OVERALL INTEGRATION: The digital LKPD integrates technology, local culture, and meaningful learning approaches to create interactive, contextual, and student-centered learning experiences.

Figure 1. Structural Design Components of the Ethnoscience-Based LKPD for IPAS Learning

The results of the flowchart and storyboard development show that the ethnoscience-based digital LKPD was systematically, interactively, and contextually designed through stages of problem orientation, local culture exploration, ethnoscience projects, reflection, and evaluation of scientific literacy and critical thinking. Interactive multimedia design and the integration of local culture help create authentic, meaningful, and relevant learning experiences for students. These findings indicate that the ethnoscience-based digital LKPD has the potential to improve student engagement, scientific literacy, and critical thinking skills in accordance with the characteristics of the Merdeka Curriculum.

The preparation of the research instruments was conducted systematically to support the development and evaluation of the ethnoscience-based digital LKPD in IPAS learning. The instruments included needs and user response questionnaires, expert validation sheets, scientific literacy and critical thinking tests, observation sheets, and interview guidelines for teachers and students. The instrument development referred to indicators of scientific literacy, scientific reasoning, problem solving, and contextual learning in line with the characteristics of the Merdeka Curriculum and 21st-century learning. In addition, the instruments were designed to comprehensively measure the validity, practicality, and effectiveness of the LKPD through quantitative and qualitative approaches. The instrument development also considered the integration of local culture, ethnoscience projects, interactive multimedia, and exploratory activities in IPAS learning.

Table 6. Blueprint of the Assessment Instruments for the Ethnoscience-Based LKPD in IPAS Learning

| Instrument | Focus | Indicators | Purpose |
|--------------------------|-----------------------------|---|-----------------------------|
| Student questionnaire | Digital media needs | Interest in LKPD and multimedia | Identify students' needs |
| Teacher questionnaire | Teaching material needs | LKPD based on the Merdeka Curriculum | Identify teachers' needs |
| Material validation | Feasibility of IPAS content | Scientific literacy and ethnoscience | Product content validation |
| Media validation | Multimedia quality | Display and navigation | Media validation |
| Language validation | Language readability | Clarity and age appropriateness | Language validation |
| Scientific literacy test | Scientific literacy | Observation and reasoning | Measure scientific literacy |
| Critical thinking test | Students' HOTS | Analysis and problem solving | Measure critical thinking |
| Observation | Learning activities | Participation and exploration | Observe implementation |
| Teacher interview | Teachers' perceptions | Ease of use and effectiveness of LKPD | Teacher qualitative data |
| Student interview | Learning experiences | Motivation and conceptual understanding | Students' responses |

The results of the instrument development indicate that all instruments were designed in an integrated manner to measure the needs, validity, implementation, and effectiveness of the ethnoscience-based digital LKPD in IPAS learning. Questionnaires were used for analyzing students' and teachers' needs, validation sheets were used to assess content, media, and language, while scientific literacy and critical thinking tests were developed based on indicators of scientific literacy, scientific reasoning, and problem solving. In addition, observations and interviews were used to measure student engagement, learning effectiveness, and user responses. These findings indicate that the instruments support systematic product evaluation in accordance with the characteristics of 21st-century IPAS learning and the Merdeka Curriculum.

The development of the digital LKPD was carried out by integrating ethnoscience, interactive multimedia, and exploratory activities to improve elementary school students' scientific literacy and critical thinking skills. IPAS materials were presented contextually through images, videos, animations, QR codes, and local culture-based activities so that students could understand scientific concepts through real experiences. Learning activities were designed based on observation, investigation, problem solving, and project-based learning to encourage scientific reasoning and active student engagement. The integration of multimedia and digital technology also supports engaging and flexible learning that aligns with the characteristics of 21st-century education and the Merdeka Curriculum.

Table 7. Components of the Development Results of Ethnoscience-Based LKPD for IPAS Learning

| Components | Development Results | Purpose | Integration |
|-------------------------|--|---|------------------------------------|
| Digital LKPD | Interactive digital format | Supporting learning | flexible Digital learning |
| Contextual images | Cultural and local environmental visuals | Facilitating understanding | IPAS Visual learning |
| Learning videos | Local cultural exploration videos | Increasing motivation | learning Multimedia learning |
| Animation | Visualization of abstract concepts | Clarifying concepts | scientific Interactive multimedia |
| QR code | Access to videos and learning resources | Facilitating access to information | Technology integration |
| Ethnoscience activities | Exploration of culture and environment | Connecting science with real life | Ethnoscience & contextual learning |
| Exploration activities | Local observation and investigation | Developing inquiry | scientific Inquiry learning |
| Critical thinking | Analytical and problem-solving tasks | Developing HOTS | Critical thinking |
| Project-based learning | Local culture-based projects | Developing collaboration and creativity | PjBL |
| Scientific literacy | Scientific reasoning and data interpretation | Improving literacy | scientific Scientific literacy |

The development results indicate that the ethnoscience-based digital LKPD was successfully designed by integrating interactive multimedia such as images, videos, animations, and QR codes to support engaging and contextual IPAS learning. The materials were developed based on local culture and the surrounding environment through investigation activities, problem solving, reflection, and ethnoscience projects, enabling the enhancement of students' engagement, scientific reasoning, scientific literacy, and critical thinking skills. The integration of digital technology and project-based learning demonstrates that the LKPD has the potential to support innovative IPAS learning in accordance with 21st-century learning characteristics and the Merdeka Curriculum.

Product validation conducted by material, media, and language experts showed that the ethnoscience-based digital LKPD was categorized as highly valid, with minor revisions in aspects of language, multimedia, and the strengthening of critical thinking activities. The validation was carried out based on indicators of digital teaching materials, scientific literacy, and contextual learning. These findings confirm that the product has met the feasibility standards in terms of content, media, and language, making it suitable for use in ethnoscience- and digital technology-based IPAS learning.

| VALIDATOR | ASPECT | RESULT | KEY FINDINGS |
|---|---|---------------------------|--|
| CONTENT EXPERT (Ahli Materi) | Alignment of IPAS content | 92% – Very Valid | Contextual content aligned with Merdeka Curriculum |
| | Integration of ethnosience & science literacy | 90% – Very Valid | Ethnosience reflection needs to be strengthened |
| | Critical thinking & problem solving | 89% – Very Valid | Need additional contextual analysis questions |
| MEDIA EXPERT (Ahli Media) | Visual design and appearance | 94% – Very Valid | Attractive design and suitable for elementary students |
| | Interactive multimedia | 93% – Very Valid | Multimedia increases student engagement |
| | Digital navigation | 91% – Very Valid | Navigation is easy and responsive |
| LANGUAGE EXPERT (Ahli Bahasa) | Language readability | 90% – Very Valid | Language is communicative and easy to understand |
| | Sentence structure | 89% – Very Valid | Scientific terms are simplified |
| | Instructions for use | 92% – Very Valid | Instructions are clear and easy to understand |
| OVERALL AVERAGE | PRODUCT VALIDITY | 91.1% – Very Valid | Feasible to use with minor revisions |

Figure 2. Expert Validation of the Development of Ethnosience-Based LKPD for IPAS Learning

The validation results revealed that the ethnosience-based digital LKPD obtained an average score of 91.1%, categorized as highly valid by material, media, and language experts. Material experts assessed that the LKPD was aligned with the IPAS learning outcomes of the Merdeka Curriculum and successfully integrated ethnosience, scientific literacy, and critical thinking in a contextual manner. Media experts evaluated the appearance, interactive multimedia, and digital navigation as attractive, while language experts considered the language to be communicative and easy to understand. Minor revisions were made to the multimedia display, usage instructions, and contextual analysis activities. These findings indicate that the LKPD is appropriate for use as an IPAS learning medium to support scientific literacy and critical thinking among elementary school students.

| ASPECT OF REVISION | SUGGESTION | ACTION TAKEN | RESULT |
|----------------------------|---|---|--------------------------------------|
| 1. Science Content (IPAS) | Strengthen real-life context | Add examples from local culture | Content more applicable |
| 2. Ethnosience Integration | Clarify ethnosience activities | Add environmental exploration | Learning more authentic |
| 3. Science Literacy | Strengthen scientific reasoning | Add observation and data interpretation | Literacy more integrated |
| 4. Critical Thinking | Analysis questions still limited | Add problem solving and reflection | HOTS more developed |
| 5. Visual Design | Design is less attractive | Improve layout and illustrations | More child-friendly appearance |
| 6. Multimedia | Videos and animations need optimization | Add multimedia and QR codes | Learning more interactive |
| 7. Digital Navigation | Instructions not clear enough | Simplify menu and access | LKPD easier to use |
| 8. Language | Scientific terms are too difficult | Simplify the language | Language more communicative |
| 9. Activity Instructions | Instructions not detailed | Clarify steps of activities | Activities more systematic |
| 10. Final Product | Minor revisions needed | Comprehensive improvement | Product is highly valid and feasible |

KEY TAKEAWAY: Revisions were made based on suggestions, resulting in a more applicable, authentic, engaging, and high-quality digital LKPD.

Figure 3. Product Revision of the Development of Ethnosience-Based LKPD for IPAS Learning

The LKPD revisions were conducted based on expert suggestions to improve the suitability of the material, the integration of ethnosience and scientific literacy, the

simplification of language, the strengthening of critical thinking and problem-solving activities, as well as the optimization of interactive multimedia and digital navigation. The development of images, videos, animations, and QR codes was carried out to make the LKPD more attractive and easier for elementary school students to use. The gradual revisions resulted in a product categorized as highly valid and suitable for implementation in ethnosience- and digital technology-based IPAS learning.

The revision results showed that the ethnosience-based digital LKPD was improved in aspects of material content, ethnosience integration, interactive multimedia, digital navigation, and language readability based on validator feedback. Revisions included the addition of local cultural content, exploratory activities, observation tasks, problem-solving exercises, and scientific reflection activities to strengthen students' scientific literacy and critical thinking skills. Visual displays, videos, animations, and QR codes were also enhanced to become more interactive and aligned with the characteristics of elementary school students. After revision, the LKPD achieved a highly valid category and was considered suitable for use in IPAS learning based on the Merdeka Curriculum.

A limited trial was conducted to determine the implementation, practicality, and students' responses toward the ethnosience-based digital LKPD through project-based learning and local cultural exploration. The LKPD utilized interactive multimedia such as images, videos, animations, and QR codes to assist students in understanding IPAS concepts concretely. The implementation results showed that the LKPD was able to increase active participation, learning motivation, scientific exploration, and student engagement in project-based learning activities. In addition, students demonstrated high enthusiasm toward digital learning that connected IPAS concepts with local culture and the surrounding environment.

Table 8. Limited Trial Implementation of the Ethnosience LKPD in IPAS Learning

| Implementation Aspect | Observation Indicators | Main Findings |
|-----------------------------|---|---|
| Limited trial | Learning implementation | The LKPD was implemented effectively, systematically, and in accordance with the learning sequence. |
| Digital LKPD implementation | Utilization of digital media | Students actively used the digital LKPD during IPAS learning activities. |
| Ethnosience integration | Exploration of local culture and environment | Learning became more contextual and closely related to students' experiences. |
| Exploration activities | Scientific inquiry and simple observation | Students became more active in observing, questioning, and conducting investigations. |
| Student engagement | Discussion, collaboration, and interaction | Student participation and communication improved during the learning process. |
| Critical thinking | Problem solving and reflection | Students' analytical and reflective abilities began to develop. |
| Interactive multimedia | Use of videos, animations, images, and QR codes | Digital media increased the attractiveness and interactivity of learning. |
| Student responses | Learning motivation and comfort | Students showed positive responses and found learning more enjoyable. |
| Teacher responses | Practicality of LKPD usage | Teachers considered the LKPD easy to use and supportive of contextual learning. |
| Scientific literacy | Scientific literacy and reasoning | Students began to relate IPAS concepts to real-life phenomena. |

The results of the limited trial indicated that the ethnoscience-based digital LKPD functioned well and received positive responses from both students and teachers. Project-based learning and local cultural exploration increased student engagement in observation, discussion, investigation, and contextual problem solving. Interactive multimedia such as videos, animations, images, and QR codes made learning more interesting and easier to understand. In addition, students demonstrated improved learning motivation, scientific inquiry skills, and confidence in presenting their observations. Teachers assessed that the LKPD was able to create a more contextual, interactive, and Kurikulum Merdeka-oriented IPAS learning environment. These findings indicate that the LKPD has a high level of practicality and implementation feasibility in improving elementary students' scientific literacy and critical thinking skills.

A large-scale trial was conducted to determine the practicality and effectiveness of the ethnoscience-based digital LKPD through project-based learning, local cultural exploration, and scientific inquiry. The data were analyzed using descriptive analysis and N-gain. The results showed that the LKPD had a high level of practicality and significantly improved student learning engagement. Furthermore, the LKPD was proven effective in improving learning outcomes, scientific literacy, scientific reasoning, and students' critical thinking skills through contextual learning based on local culture and interactive multimedia.

Table 9. Large-Scale Trial of the Ethnoscience LKPD in IPAS Learning

| Large-Scale Trial Aspect | Implementation Results | Measurement Indicators | Findings |
|---------------------------|--|---|--|
| Product practicality | The LKPD was easy for students and teachers to use | Ease of use and digital accessibility | The product was practical and flexible |
| Learning implementation | Learning was interactive and contextual | Project activities and local cultural exploration | Students were active during learning |
| Student learning outcomes | Learning achievement scores increased | Comparison of pretest and posttest results | Learning outcomes improved significantly |
| Scientific literacy | Scientific literacy skills improved | Scientific reasoning and data interpretation | Students better understood IPAS concepts |
| Critical thinking | Analytical and problem-solving skills improved | HOTS and scientific reflection | Students became more critical in solving problems |
| Student engagement | Participation and learning motivation increased | Discussion, collaboration, and exploration | Students became more enthusiastic and communicative |
| Interactive multimedia | Videos, animations, and QR codes supported concept understanding | Student interaction with digital media | Learning became more engaging |
| Ethnoscience integration | Local culture made learning more contextual | Connection of concepts with the surrounding environment | Concept understanding became more meaningful |
| Teacher responses | Teachers gave very positive responses | Practicality and effectiveness of the LKPD | Supported the implementation of Kurikulum Merdeka |
| Product effectiveness | The digital LKPD effectively improved student abilities | N-gain analysis and learning observation | The product was effectively used in elementary IPAS learning |

The results of the large-scale trial showed that the ethnoscience-based digital LKPD had an excellent level of practicality and effectiveness in elementary school IPAS learning. The product was easy to use through simple navigation, interactive multimedia, and activities based on local culture. Project-based learning and cultural exploration increased student engagement in observation, scientific inquiry, and problem solving, while also improving learning outcomes, scientific literacy, scientific reasoning, and critical thinking. The use of images, videos, animations, and QR codes helped students understand IPAS concepts more concretely and attractively. Teachers also gave positive responses because the LKPD supported the implementation of Kurikulum Merdeka and 21st-century interactive and contextual learning.

Formative evaluation was conducted through expert validation, product revision, limited trials, observation, and user responses, while summative evaluation was conducted through pretest-posttest analysis involving 28 students using descriptive statistics, mastery percentage, and N-gain analysis. The evaluation results showed that the ethnoscience-based digital LKPD was able to improve student learning engagement, scientific reasoning, and problem-solving skills through contextual learning based on local culture and interactive multimedia. In addition, teachers and students gave highly positive responses regarding the practicality and effectiveness of the LKPD in supporting the implementation of Kurikulum Merdeka.

| EVALUATION COMPONENT | ASSESSMENT INDICATOR | DESCRIPTIVE STATISTICS (n = 28) | CATEGORY |
|----------------------|---|--------------------------------------|---------------|
| FORMATIVE EVALUATION | Validity of content, media, and language | Average validation: 91,1% | Very Valid |
| | Student responses to digital LKPD | Average student response: 89% | Very Good |
| | Student engagement in learning | Average student activity: 87% | Very Active |
| | Implementation of LKPD in IPAS learning | Average implementation: 90% | Very Good |
| SUMMATIVE EVALUATION | Student pretest score | Mean = 61,4 | Low |
| | Student posttest score | Mean = 84,7 | High |
| | Improvement in scientific literacy | N-gain = 0,71 | High |
| | Improvement in critical thinking (HOTS & problem solving) | N-gain = 0,69 | Medium-High |
| | Student mastery (completeness) | 25 of 28 students (89,3%) | Very Good |
| | Teacher response (practicality and effectiveness) | Teacher response: 92% | Very Positive |
| | Student response (motivation and interest) | Student response: 90% | Very Positive |
| | | | |

KEY TAKEAWAY: The digital LKPD is highly valid, effective in improving learning outcomes, and receives excellent responses from students and teachers.

Figure 4. Evaluation of the Development of the Ethnoscience LKPD in IPAS Learning

The formative evaluation results showed that the ethnoscience-based digital LKPD obtained a “very valid” and “very good” category during the validation stage, limited trial, and learning implementation. Students demonstrated high engagement in project-based learning and local cultural exploration. The summative evaluation involving 28 students showed significant improvements in learning outcomes, scientific literacy, and critical thinking, with the average score increasing from 61.4 to 84.7. The N-gain for scientific literacy was 0.71, categorized as high, while critical thinking achieved 0.69, categorized as moderate to high, with learning mastery reaching 89.3%. Teachers and students also provided highly positive responses regarding the practicality and effectiveness of the product. These findings indicate that the ethnoscience-based digital LKPD effectively supports interactive and contextual IPAS learning in elementary schools.

The analysis of improvements in scientific literacy and critical thinking using descriptive statistics and N-gain based on pretest and posttest results showed that the ethnoscience-based digital LKPD was able to improve students' scientific literacy, scientific reasoning, data interpretation, problem solving, and critical thinking through contextual learning, interactive multimedia, and local cultural exploration. These findings confirm that the integration of ethnoscience and digital technology has a positive impact on the development of higher-order thinking skills among elementary school students.

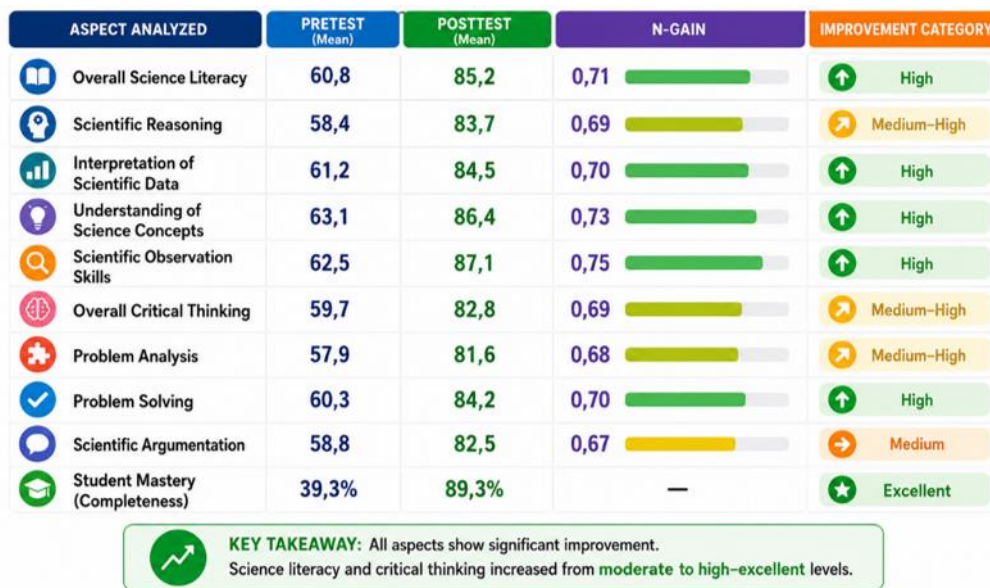


Figure 5. Analysis of the Improvement of Scientific Literacy and Critical Thinking in IPAS Learning Using the Ethnoscience LKPD

The results of the descriptive and N-gain analyses showed that the ethnoscience-based digital LKPD effectively improved elementary school students' scientific literacy and critical thinking skills. The average scientific literacy score increased from 60.8 to 85.2, with an N-gain value of 0.71 categorized as high. The improvement was especially visible in students' scientific reasoning, data interpretation, and understanding of IPAS concepts through contextual and exploratory learning activities. Students became more active in connecting scientific concepts with local culture and their surrounding environment, while the use of interactive multimedia such as videos, animations, images, and QR codes increased learning motivation and engagement during the learning process.

In addition, students' critical thinking skills also improved significantly, with the average score increasing from 59.7 to 82.8 and an N-gain value of 0.69 categorized as moderate to high. The improvement was mainly observed in students' abilities to analyze problems, solve problems systematically, and communicate logical arguments during scientific inquiry and project-based learning activities. Furthermore, the percentage of learning mastery increased from 39.3% to 89.3% after the implementation of the ethnoscience-based digital LKPD. These findings indicate that the integration of local culture, interactive multimedia, and project-based exploratory learning effectively supports

the development of students' scientific literacy and higher-order thinking skills in accordance with the objectives of the Merdeka Curriculum and 21st-century learning.

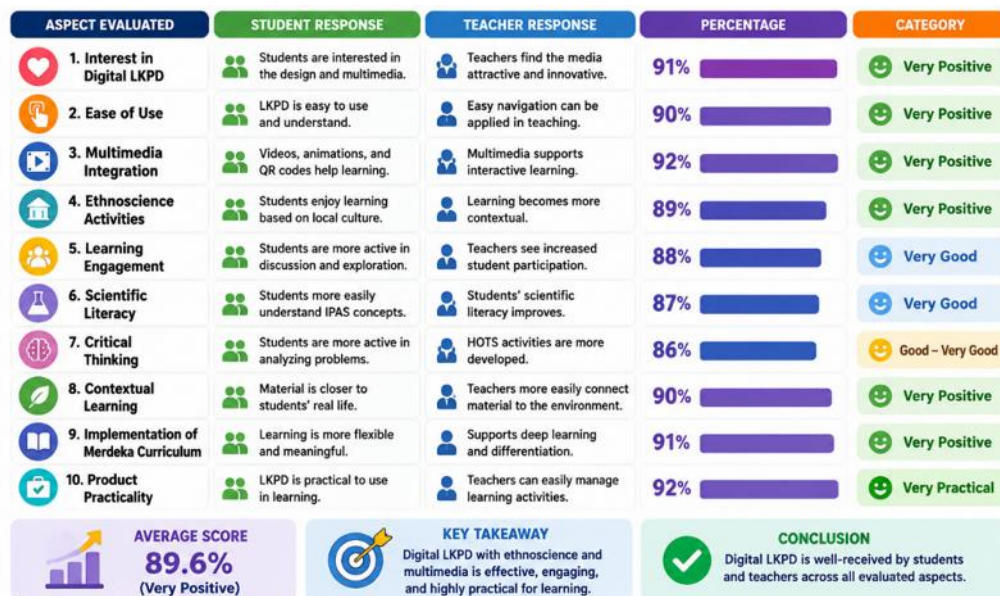


Figure 6. Student and Teacher Responses toward the Ethnoscience LKPD in IPAS Learning

The evaluation through questionnaires, interviews, observations, and reflections indicated that students responded very positively because the learning process became more engaging, interactive, and contextual through the use of videos, animations, QR codes, and ethnoscience-based activities related to the surrounding environment. Teachers also assessed that the digital student worksheets supported a more active, exploratory, and relevant science and social studies learning process in accordance with the needs of 21st-century education.

The evaluation results showed that both students and teachers gave highly positive responses to the use of ethnoscience-based digital worksheets in science and social studies learning. Students found the learning activities more interesting and easier to understand through videos, animations, images, and QR codes integrated with local cultural exploration. Student participation in discussions, observations, problem-solving, and scientific inquiry also increased. Teachers considered the worksheets practical to use and supportive of differentiated learning, project-based learning, and deep learning in line with the Merdeka Curriculum. The integration of ethnoscience helped connect science and social studies concepts with the surrounding environment, making learning more contextual and meaningful. These findings indicate that ethnoscience-based digital worksheets have a very high level of practicality and acceptance in improving elementary school students' scientific literacy and critical thinking skills.

The refinement of the final product was carried out based on the results of implementation, formative and summative evaluations, as well as feedback from teachers and students. Revisions focused on optimizing the materials, integrating ethnoscience, strengthening scientific literacy and critical thinking, improving interactive multimedia, and enhancing the digital interface and navigation to make them more effective and user-friendly. The improvement results demonstrated that the ethnoscience-based digital

worksheets became more interactive, contextual, and effective in enhancing students' scientific literacy and critical thinking through project-based learning and local cultural exploration.



Figure 7. Improvement of Ethnoscience-Based Worksheets for Science and Social Studies Learning

The refinement results indicated that the ethnoscience-based digital worksheets improved in terms of materials, learning activities, interactive multimedia, digital navigation, and visual design to align with the characteristics of elementary school students and the Merdeka Curriculum. Scientific literacy and critical thinking activities were strengthened through observation, scientific reasoning, problem-solving, and reflection based on local culture. Multimedia components such as videos, animations, and QR codes were also enhanced to increase student engagement and learning motivation. Teachers and students provided positive responses regarding the ease of use and the meaningfulness of contextual ethnoscience-based learning. Overall, the worksheets were considered highly feasible, practical, and effective in improving elementary school students' scientific literacy and critical thinking skills.

The establishment of ethnoscience-based digital worksheets as the final product was based on expert validation results, limited and large-scale trials, as well as formative and summative evaluations showing that the product fulfilled the aspects of validity, practicality, and effectiveness. The worksheets were designed by integrating ethnoscience, scientific literacy, critical thinking, interactive multimedia, and project-based learning according to the characteristics of the Merdeka Curriculum and 21st-century learning. The evaluation results demonstrated that the product was able to improve scientific literacy, scientific reasoning, problem-solving, and student engagement through the integration of local culture and digital technology. Teachers and students also provided highly positive responses regarding the interactivity and meaningfulness of the learning process.

| ASPECT OF FINAL PRODUCT | MAIN INDICATOR | RESULT & CATEGORY |
|--|--|---|
| 1. Product Validity | Content, media, and language feasibility | Expert validation 91.1% categorized as very valid VERY VALID |
| 2. Product Practicality | Ease of use and implementation | Teacher response 92% and student response 90%, categorized as very practical VERY PRACTICAL |
| 3. Learning Effectiveness | Improvement in student learning achievement | Posttest score increased to 84.7 categorized as very effective VERY EFFECTIVE |
| 4. Science Literacy | Scientific literacy and reasoning | N-gain 0.71 indicates high improvement HIGH |
| 5. Critical Thinking | Problem solving and HOTS | N-gain 0.69 in the medium-high category MEDIUM-HIGH |
| 6. Ethnoscience Integration | Contextual learning based on local culture | Local cultural integration works very well EXCELLENT |
| 7. Interactive Multimedia | Interactivity and learning motivation | Videos, animations, and QR codes function optimally EXCELLENT |
| 8. Student Engagement | Discussion, exploration, and investigation | Student learning activities increase and are very active VERY ACTIVE |
| 9. Independent Curriculum Implementation | Deep learning and differentiated instruction | Product is highly aligned with 21st century learning HIGHLY SUITABLE |
| 10. Final Digital LKPD Product | Validity, practicality, and effectiveness | Digital LKPD is declared very feasible for IPAS learning in elementary school VERY FEASIBLE |

Figure 8. Final Product of Ethnoscience-Based Worksheets for Science and Social Studies Learning

The final product evaluation results showed that the ethnoscience-based digital worksheets fulfilled all feasibility indicators as a **valid, practical, and effective** learning medium **for elementary school science and social studies** education. Product validity was demonstrated through **expert assessment results with an average percentage of 91.1%, categorized as highly valid**, while product **practicality** was reflected in the highly positive responses from teachers and students regarding ease of use, interactive multimedia display, and contextual learning based on local culture. In addition, the product effectiveness was evident from the improvement in **students' learning outcomes**, scientific literacy, and **critical thinking skills** after using the digital worksheets, **with an N-gain score of 0.71** for scientific literacy and 0.69 for critical thinking skills. The integration of ethnoscience, project activities, scientific inquiry, and interactive multimedia successfully increased student engagement and learning motivation during science and social studies learning. These findings confirm that ethnoscience-based digital worksheets are appropriate to be used as a final product **to support the implementation of the Merdeka Curriculum and 21st-century learning** in elementary schools in a more interactive, contextual, and meaningful manner.

Discussion

The research findings showed that ethnoscience-based digital worksheets contributed significantly **to improving the quality of elementary school science and social studies learning**, particularly in **students' scientific literacy and critical thinking skills**. The product achieved very high validity with an average score of 91.1% from material, media, and **language experts**, indicating **the suitability of the content**, readability, media interactivity, and relevance to the Merdeka Curriculum. **The integration of local culture made learning more contextual** and meaningful because **students** learned scientific concepts through real-life experiences and their surrounding environment [19], [20].

The implementation of ethnoscience-based digital worksheets increased student involvement in project-based learning, scientific inquiry, observation, discussion, and

problem-solving activities. The use of interactive multimedia such as videos, animations, images, and QR codes enhanced learning motivation and helped students understand science and social studies concepts more concretely [21], [22]. Learning also became more flexible, collaborative, and student-centered in accordance with the characteristics of 21st-century learning and the deep learning approach promoted in the Merdeka Curriculum [23], [24].

Empirically, the N-gain results indicated significant improvement in scientific literacy with a score of 0.71 and critical thinking skills with a score of 0.69, particularly in scientific reasoning, data interpretation, problem-solving, and scientific argumentation. These findings demonstrate that the integration of ethnoscience, project-based learning, and digital multimedia effectively develops students' higher-order thinking skills [25], [26]. Theoretically and practically, this study confirms that ethnoscience-based digital worksheets can become an innovative approach to science and social studies learning that supports scientific literacy, critical thinking, creativity, collaboration, and students' ecological awareness in the Society 5.0 era [27], [28].

4. CONCLUSION

This study shows that the development of ethnoscience-based digital student worksheets through the ADDIE model successfully produced an elementary school science and social learning product that is valid, practical, and effective in improving students' scientific literacy and critical thinking skills. The integration of local culture, interactive multimedia, and project-based learning activities was able to create learning that is more contextual, exploratory, and meaningful in accordance with the characteristics of the Merdeka Curriculum and 21st-century learning. The results of expert validation indicated a very valid category, while the product implementation demonstrated highly positive responses from teachers and students regarding the practicality and interactivity of the digital worksheets. In addition, the results of descriptive analysis and N-gain showed significant improvements in students' scientific literacy, scientific reasoning, problem-solving abilities, and critical thinking skills after using the product. These findings confirm that ethnoscience-based digital worksheets are not only effective as a learning medium for science and social studies, but also make a strategic contribution to integrating scientific literacy, digital technology, and local wisdom in supporting more humanistic, innovative, and sustainable elementary school learning in the Society 5.0 era.

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