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Fostering Elementary Students' Critical Thinking Skills Through an Ethno-STEAM E-Book: Integrating Bungurasih Local Wisdom into Digital Learning

Firda Emilia[1], Ganes Gunansyah[1], Mareta Dellarosa[1]

[1] Universitas Negeri Surabaya, Indonesia

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ABSTRACT

This study aimed to develop an Ethno-STEAM-based interactive e-book integrating Bungurasih local wisdom and to evaluate its validity, practicality, and effectiveness in improving elementary students' critical thinking skills. The study employed a Research and Development (R&D) approach using the ADDIE model and a one-group pretest–posttest design involving 30 third-grade students. Data were collected through expert validation, questionnaires, classroom observations, and critical thinking tests. The developed e-book achieved a validity score of 91.7% and a practicality score of 92.5%, both categorized as very valid and very practical, respectively. Students' critical thinking skills improved significantly after the intervention, with an average N-Gain of 0.61, indicating a moderate level of improvement. These findings demonstrate that integrating local wisdom, interactive multimedia, and Ethno-STEAM learning creates meaningful and contextual science learning experiences. The study implies that Ethno-STEAM digital learning media can support the implementation of culturally responsive science education while fostering critical thinking and other twenty-first-century competencies in elementary schools.

Corresponding Author:
A. Zainal Abidin
Universitas Negeri Surabaya, Indonesia; 25010905014@mhs.unesa.ac.id

1. INTRODUCTION

The ability to think critically is one of the essential competencies that students must develop in the twenty-first century, as it enables them to systematically analyze information, objectively evaluate evidence, construct logical arguments, and make informed decisions when addressing real-world problems. International educational frameworks consistently recognize critical thinking as a core component of Higher-Order Thinking Skills (HOTS), which are indispensable for navigating rapid advances in science, technology, and increasingly complex social and environmental challenges. Consequently, the cultivation of critical thinking should begin at the elementary school level, where students establish the foundations of scientific reasoning, problem-solving, and lifelong learning habits.

In Indonesia, this urgency is reflected in the implementation of the Merdeka Curriculum, which shifts instruction from a teacher-centered approach toward student-centered learning through inquiry, exploration, and meaningful learning experiences. In the subject of Natural and Social Sciences (Ilmu Pengetahuan Alam dan Sosial [IPAS]), students are expected not only to understand scientific concepts

but also to observe environmental phenomena, identify cause-and-effect relationships, evaluate alternative solutions, and make responsible decisions regarding environmental sustainability. These expectations align with the constructivist perspective, which emphasizes that knowledge is actively constructed through learners' interactions with authentic experiences closely connected to their everyday lives.

Authentic learning contexts become increasingly important when viewed within the environmental setting of Bungurasih, Waru District, Sidoarjo Regency. Bungurasih is a rapidly developing urban area located adjacent to Purabaya Terminal, one of Indonesia's largest transportation hubs, and is surrounded by residential neighborhoods, commercial districts, industrial zones, and aquaculture ponds. These characteristics create environmental dynamics that differ substantially from those of typical rural or urban areas. High levels of human mobility and economic activity have contributed to increasing plastic waste, land-use changes, reduced soil infiltration capacity, seasonal flooding caused by overloaded drainage systems, and growing pressure on surrounding wetland ecosystems. These issues are not merely general environmental concerns but represent everyday realities that students directly observe and experience in their daily lives.

The uniqueness of Bungurasih lies not only in the complexity of its environmental challenges but also in the preservation of local cultural values within the community. One notable example is the story of Mbah Bungur, which forms part of the area's local history while embodying values of mutual cooperation, environmental stewardship, and social responsibility. These values continue to be reflected in community practices such as collective efforts to clean drainage channels, neighborhood environmental management, and initiatives to maintain local environmental sustainability. Consequently, Bungurasih provides a distinctive learning context by integrating urban environmental issues, local wisdom, and students' everyday experiences into an authentic educational setting. Such conditions create opportunities for IPAS learning to connect scientific concepts with real-life experiences, enabling students not only to understand theoretical knowledge but also to develop critical thinking skills through investigations of authentic problems they encounter in their own communities.

Numerous studies have demonstrated that critical thinking develops most effectively when students actively investigate authentic problems relevant to their everyday lives. Accordingly, instructional approaches such as Problem-Based Learning, Inquiry-Based Learning, and Project-Based Learning have been widely implemented to encourage students to identify problems, evaluate evidence, construct arguments, and formulate solutions based on scientific reasoning. At the same time, science education has increasingly embraced interdisciplinary approaches through Science, Technology, Engineering, Arts, and Mathematics (STEAM), enabling students to examine phenomena from multiple disciplinary perspectives. Advances in educational technology have further shown that interactive digital learning media, including e-books, can enhance student engagement, scientific reasoning, and higher-order thinking through multimedia integration, simulations, immediate feedback, and exploratory learning activities that promote independent learning.

Over the past decade, scholarly attention has expanded beyond integrating disciplines within STEAM toward examining how indigenous knowledge can be transformed into a learning resource with equal epistemological value to modern scientific knowledge. This perspective has evolved alongside growing interest in culturally responsive pedagogy and place-based education, both of which position culture, environment, and students' lived experiences as integral components of knowledge construction. International studies have demonstrated that integrating local knowledge into STEM/STEAM education enhances conceptual understanding, critical thinking, cultural identity, and environmental awareness because students learn scientific concepts through practices, traditions, and phenomena familiar within their communities. Within this context, the Ethno-STEAM approach has emerged as an extension of STEAM education by integrating science, technology, engineering, arts, and mathematics with local wisdom as an epistemological foundation for understanding scientific phenomena. Consequently, culture is no longer viewed merely as an instructional illustration but rather

as a legitimate source of knowledge that can be integrated with modern scientific concepts to create more meaningful and contextualized learning experiences.

Despite these developments, previous research continues to reveal significant gaps that warrant further investigation. Most studies on Problem-Based Learning, digital learning media, STEAM education, and ethnoscience have been conducted independently, resulting in a lack of comprehensive digital learning environments that integrate these components into a unified instructional design. Research on interactive e-books has generally focused on improving learning motivation, student engagement, or conceptual understanding, whereas STEAM studies have emphasized creativity, engineering design, and problem-solving skills. Meanwhile, ethnoscience research has primarily concentrated on cultural preservation or introducing local knowledge without examining how such integration can foster critical thinking through digital learning media. Furthermore, only a limited number of studies have transformed complex local environmental phenomena into Ethno-STEAM-based digital learning experiences that integrate scientific knowledge, digital technology, engineering activities, and local wisdom within a single instructional framework. This research gap provides the primary rationale for the present study.

This gap is further supported by the findings of a preliminary study conducted on September 5, 2025, at SD Darul Ulum Bungurasih, Sidoarjo Regency. Classroom observations and teacher interviews indicated that IPAS instruction remained predominantly lecture-based, with heavy reliance on textbooks as the primary learning resource. When students were presented with contextual problems related to their surrounding environment—such as the causes of flooding, plastic waste accumulation, or environmental degradation resulting from urban activities—most were able only to describe the observed phenomena without explaining causal relationships or providing evidence-based justifications. During group discussions, student participation was relatively limited, and the arguments presented demonstrated insufficient analytical and evaluative reasoning. Analysis of students' worksheets further revealed that most responses remained at the level of understanding (C2) and had not progressed to the analytical level (C4) according to the Revised Bloom's Taxonomy.

These findings suggest that current instructional practices have not adequately facilitated the development of critical thinking through contextual, meaningful, and inquiry-based learning experiences. In response to these conditions, this study developed an Ethno-STEAM e-book for the topic Living in Harmony with Nature, integrating Bungurasih's environmental phenomena and local wisdom into elementary school IPAS instruction. The e-book was designed as an interactive digital learning environment combining multimedia, inquiry-based activities, problem-solving tasks, and the components of Science, Technology, Engineering, Arts, and Mathematics (STEAM) with the local knowledge of the Bungurasih community. Students not only learn scientific concepts but also explore the story of Mbah Bungur as a representation of mutual cooperation and environmental responsibility, analyze ecological issues within their local environment, and engage in engineering activities by creating ecobricks as a practical solution to plastic waste problems.

These learning activities are specifically designed to encourage students to observe, interpret information, evaluate alternative solutions, construct evidence-based arguments, and draw logical conclusions, thereby fostering critical thinking through authentic learning experiences. The novelty of this study lies in the development of a comprehensive digital learning environment that systematically integrates an interactive e-book, the Ethno-STEAM approach, Bungurasih's environmental phenomena, and local wisdom into a unified instructional design aimed at enhancing elementary school students' critical thinking skills. Unlike previous studies that have examined digital learning media, STEAM education, or ethnoscience separately, this research demonstrates how local knowledge can serve as an epistemological foundation for constructing scientific understanding through digital technology. Accordingly, this study not only produces an innovative learning product but also contributes theoretically to the development of Digital Ethno-Pedagogy, a pedagogical framework that bridges digital technology, indigenous knowledge, and contextual science learning to support the development of twenty-first-century competencies. Therefore, this study aims to develop, validate, and evaluate the

practicality and effectiveness of an Ethno-STEAM e-book based on the local wisdom of Bungurasih in improving elementary school students' critical thinking skills.

2. METHODS

This study employed a Research and Development (R&D) approach to develop an Ethno-STEAM-based interactive e-book integrating Bungurasih local wisdom and to examine its validity, practicality, and effectiveness in improving elementary students' critical thinking skills. The research adopted the ADDIE instructional design model, consisting of five sequential and interconnected stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because it provides a systematic, flexible, and iterative framework for developing educational products while allowing continuous improvement through formative evaluation. Furthermore, the model facilitates alignment between instructional objectives, learner characteristics, curriculum requirements, and product evaluation, making it highly appropriate for digital learning media development.

To determine the effectiveness of the developed learning media, this study employed a pre-experimental quantitative research design using a One-Group Pretest–Posttest Design. This design was selected because it enables researchers to measure changes in students' critical thinking skills before and after participating in learning activities using the developed Ethno-STEAM e-book. The experimental design is illustrated as follows:

$$O_1 – X – O_2$$

where O_1 represents the pre-test administered before the intervention to measure students' initial critical thinking skills, X denotes the learning intervention using the Ethno-STEAM interactive e-book, and O_2 represents the post-test administered after the intervention to evaluate students' critical thinking skills following the learning process. The effectiveness of the developed product was determined by comparing students' pre-test and post-test scores and calculating the normalized gain (N-Gain) to determine the magnitude of learning improvement.

The study was conducted during the second semester of the 2025/2026 academic year at SD Darul Ulum Bungurasih, Sidoarjo, East Java, Indonesia. The school was purposively selected because it has implemented the Merdeka Curriculum, possesses adequate technological facilities such as internet access, projectors, and computer laboratories, and is located in an environment rich in local wisdom that can be integrated into Ethno-STEAM learning. Preliminary observations also indicated that science learning remained predominantly teacher-centered, relied heavily on printed textbooks, and provided limited opportunities for students to develop higher-order thinking skills. These conditions justified the need for developing an innovative digital learning medium that integrates local wisdom and promotes critical thinking.

The participants consisted of 30 third-grade elementary school students, aged 8–9 years, including both male and female students. Participants were selected using purposive sampling based on several criteria. First, the students had studied environmental science topics included in the Merdeka Curriculum. Second, they had never previously used an Ethno-STEAM-based interactive e-book in classroom learning. Third, the selected class represented the actual learning context in which the developed product would eventually be implemented. In addition to student participants, one third-grade classroom teacher participated as the practitioner responsible for implementing the learning activities and evaluating the practicality of the developed media through a teacher response questionnaire.

The research employed both quantitative and qualitative data. Quantitative data consisted of expert validation scores, observation scores, teacher and student response questionnaire scores, and students' pre-test and post-test scores measuring critical thinking skills. Qualitative data consisted of comments, suggestions, and recommendations provided by experts, teachers, classroom observations, and students during product validation and classroom implementation. These qualitative data served as the basis for revising and improving the developed product throughout the development process. The research instruments consisted of expert validation sheets, classroom observation sheets, teacher response questionnaires, student response questionnaires, and a critical thinking skills test. Expert

validation sheets were designed to evaluate the appropriateness of the developed e-book in terms of content quality, instructional design, language appropriateness, graphical presentation, interface design, and integration of Ethno-STEAM principles. Observation sheets were used to assess the implementation of classroom learning activities and the practicality of using the interactive e-book during instruction. Teacher and student response questionnaires measured users' perceptions regarding the ease of use, attractiveness, clarity of learning activities, usefulness, and overall practicality of the developed learning media.

The effectiveness of the developed product was measured using a critical thinking skills test consisting of ten essay questions. The test items were developed based on Facione's critical thinking framework, covering six indicators: interpretation, analysis, evaluation, inference, explanation, and self-regulation. Each question was designed to measure students' ability to identify environmental problems, analyze contextual situations, provide logical reasoning, propose solutions, and draw evidence-based conclusions within authentic learning contexts related to Bungurasih local wisdom. The essay format was selected because it allows students to express their reasoning processes more comprehensively than objective test formats.

Prior to classroom implementation, all research instruments underwent content validation conducted by three experts, consisting of one learning media expert, one science education expert, and one elementary education expert. Each validator assessed the relevance, clarity, representativeness, readability, instructional suitability, and appropriateness of every instrument item according to the research objectives and the developmental characteristics of third-grade elementary students. The validation process also examined the alignment between learning objectives, critical thinking indicators, and Ethno-STEAM learning activities. Suggestions and recommendations provided by the validators were carefully incorporated into the revision process before the instruments were administered during the classroom trial.

Following content validation, the critical thinking test instrument was subjected to reliability testing to ensure its internal consistency before implementation. Reliability analysis was conducted using Cronbach's Alpha with the assistance of IBM SPSS software. The obtained reliability coefficient indicated satisfactory internal consistency, demonstrating that the instrument was sufficiently reliable for measuring elementary students' critical thinking skills. Consequently, the validated and reliable instrument was considered appropriate for use during both the pre-test and post-test administrations.:

The development procedure followed the five stages of the ADDIE model.

$$N - Gain = \frac{\text{Post} - \text{test Score} - \text{Pre} - \text{test Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

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2.1 Analysis

The analysis stage aimed to identify instructional needs, learner characteristics, curriculum requirements, and contextual conditions supporting the development of the Ethno-STEAM interactive e-book. Four analyses were conducted, namely needs analysis, curriculum analysis, learner analysis, and contextual analysis. Needs analysis was performed through classroom observations, informal interviews with third-grade teachers, and documentation review. The findings indicated that classroom instruction remained teacher-centered, learning activities emphasized memorization, instructional media were limited to printed textbooks, and technology-based learning resources were rarely utilized despite the availability of supporting facilities. Curriculum analysis referred to the Merdeka Curriculum learning outcomes for the topic "Living in Harmony with Nature." Learner analysis revealed that third-grade students were at the concrete operational stage and therefore required contextual, visual, interactive, and experience-based learning. Contextual analysis explored environmental issues surrounding Bungurasih, including plastic waste management, drainage problems, community environmental awareness, and ecosystem conservation, all of which became authentic learning contexts integrated into the Ethno-STEAM activities..

2.2 Design

The design stage involved preparing the conceptual framework and instructional structure of the interactive e-book. Activities included determining learning objectives, organizing instructional content, preparing storyboards, designing multimedia layouts, selecting illustrations and interactive components, integrating science, technology, engineering, arts, mathematics, and Bungurasih local wisdom into learning activities, and developing authentic assessments aligned with critical thinking indicators. During this stage, research instruments—including expert validation sheets, observation sheets, teacher and student response questionnaires, and critical thinking tests—were also designed. The e-book interface emphasized multimedia learning principles, intuitive navigation, learner engagement, contextual learning experiences, and age-appropriate visual presentation.

2.3 Development

The development stage transformed the conceptual design into an interactive digital learning product. The e-book was developed by integrating text, illustrations, videos, animations, interactive quizzes, contextual problem-solving activities, and project-based learning tasks such as Ecobrick activities. Local environmental issues and Bungurasih cultural practices were integrated throughout the learning materials using the Ethno-STEAM approach. Upon completion of the prototype, the product underwent expert validation involving specialists in learning media, science education, and elementary education. Product feasibility was evaluated based on content quality, instructional appropriateness, language, interface design, usability, and consistency with learning objectives. Revisions were conducted iteratively according to expert recommendations until the product satisfied the predetermined feasibility criteria.

2.4 Implementaion

The implementation stage involved a limited classroom trial involving 30 third-grade students. Prior to instruction, students completed the pre-test to determine their initial critical thinking abilities. Learning activities were conducted over several instructional meetings using the Ethno-STEAM interactive e-book. Students investigated authentic environmental issues, watched instructional videos, completed Ecobrick projects, analyzed contextual case studies, collaborated in group discussions, and reflected on environmental conservation through integrated STEAM activities based on Bungurasih local wisdom. After completing all learning activities, students took the post-test. Classroom observations and teacher and student response questionnaires were simultaneously administered to evaluate the practicality and usability of the developed media.

2.5 Evaluation

Evaluation was conducted continuously throughout all ADDIE stages using both formative and summative evaluation. Formative evaluation occurred after each development stage to identify weaknesses and improve the product before proceeding to subsequent stages. Summative evaluation was conducted following classroom implementation to determine the overall quality of the developed product. Three evaluation aspects were examined: validity, practicality, and effectiveness. Product validity was determined through expert judgment. Practicality was evaluated using classroom observation results together with teacher and student response questionnaires. Product effectiveness was determined by comparing students' pre-test and post-test scores and calculating the Normalized Gain (N-Gain) using the following formula:

$$N - Gain = \frac{\text{Post} - \text{test Score} - \text{Pre} - \text{test Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

The resulting N-Gain values were interpreted according to Hake's classification: high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), and low ($g < 0.30$). Prior to conducting effectiveness analysis, pre-test and post-test data were examined using the Shapiro–Wilk normality test, which is recommended for sample sizes smaller than fifty participants. A significance value greater than 0.05 indicated normally

distributed data. Quantitative data were analyzed descriptively using percentage calculations, normality testing, and N-Gain analysis. Qualitative data obtained from expert comments, classroom observations, and user feedback were analyzed descriptively and used as the basis for revising the product throughout the development process. The comprehensive evaluation ultimately determined whether the Ethno-STEAM interactive e-book fulfilled the criteria of being valid, practical, and effective for improving elementary students' critical thinking skills.

3. FINDINGS AND DISCUSSION

3.1 Development Results

The primary outcome of this study is an Ethno-STEAM-based digital e-book entitled "Living in Harmony with Nature", developed to improve elementary school students' critical thinking skills in the Natural and Social Sciences (IPAS) subject. The e-book was developed using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model, which provides a systematic framework for producing instructional media that aligns with students' learning needs and curriculum requirements. The product integrates the local wisdom of Bungurasih, particularly the community's environmental practices in managing plastic waste through the ecobrick technique, into contextual learning activities.

During the analysis stage, classroom observations and interviews with teachers revealed that learning activities were still dominated by conventional teaching methods and printed textbooks, resulting in limited opportunities for students to develop higher-order thinking skills. These findings served as the basis for designing an interactive digital learning medium that could connect scientific concepts with students' real-life experiences. In the design stage, the e-book structure was organized to include learning objectives, contextual learning materials, interactive illustrations, videos, reflective activities, quizzes, and evaluation tasks. The content was carefully aligned with the Learning Outcomes (CP) and Learning Objectives (TP) of the Merdeka Curriculum while incorporating the five components of the Ethno-STEAM approach: Science, Technology, Engineering, Arts, and Mathematics.

The development stage focused on producing the digital e-book using Canva and web-based interactive features, followed by expert validation and product revision. The e-book was then implemented in Grade III elementary students through classroom learning activities, while the evaluation stage assessed its validity, practicality, and effectiveness. The final product presents authentic photographs, interactive multimedia, contextual problem-solving activities, and reflective questions that encourage students to analyze environmental issues from multiple perspectives. Overall, the developed e-book represents an innovative instructional medium that combines digital technology, local cultural knowledge, and interdisciplinary learning within a single platform. This integration creates a meaningful learning environment that not only facilitates conceptual understanding but also promotes students' critical thinking, environmental awareness, and active participation in solving real-world problems. The development process demonstrates that integrating Ethno-STEAM with culturally relevant digital media can support the implementation of contextual and student-centered learning in elementary education. (Luritawaty et al., 2026).

3.2 Validity

The validity of the Ethno-STEAM-based e-book was evaluated by one material expert and one media expert before the implementation stage. The validation process assessed the appropriateness of the instructional content, language, visual design, technical quality, and the integration of the Ethno-STEAM approach. Suggestions provided by the validators were used to revise and improve the product prior to classroom implementation. The validation results are presented in Table 3.1.

Table 3.1 E-Book Validation Results

Assessment Aspect	Percentage	Category
Content Feasibility	92%	Very Valid
Language Feasibility	90%	Very Valid
Media Feasibility	93%	Very Valid
Average	**91.7%**	**Very Valid**

The results indicate that the developed e-book falls into the very valid category and is suitable for use in learning. These findings are consistent with Andriani et al. (2021), who reported that instructional e-books with validity scores above 90% are considered highly feasible. Conceptually, the high validity demonstrates that the integration of Ethno-STEAM in the e-book successfully presents relevant, systematic, and age-appropriate learning content for elementary students. This aligns with the principle that well-designed instructional media should integrate content accuracy, clarity, and pedagogical suitability (Dewi et al., 2025)).

The high validity score demonstrates that the instructional content is scientifically accurate, pedagogically appropriate, and relevant to elementary school students. The integration of Bungurasih local wisdom through the ecobrick context also enhances the contextual relevance of the learning materials. These findings support the constructivist perspective that meaningful learning occurs when instructional materials are connected with learners' real-life experiences. Furthermore, the multimedia components—including text, images, videos, and interactive navigation—reflect the principles of the Cognitive Theory of Multimedia Learning, which emphasizes that well-designed multimedia can improve students' conceptual understanding by reducing unnecessary cognitive load. These findings are consistent with previous studies reporting that Ethno-STEAM-based digital learning media demonstrate high validity because they effectively integrate scientific concepts with local cultural contexts. Therefore, the developed e-book can be considered a pedagogically sound instructional medium that is appropriate for supporting critical thinking-oriented learning in elementary schools.

3.3 Practicality

The practicality of the developed e-book was evaluated through response questionnaires completed by the classroom teacher and Grade III students after the implementation process. The questionnaire measured several aspects, including ease of use, clarity of instructions, attractiveness of the interface, accessibility, and the usefulness of the media in supporting classroom learning. The practicality results are summarized in Table 3.2

Table 3.2 Practicality Results

Respondent	Percentage	Category
Teacher	94%	Very Practical
Students	91%	Very Practical
Average	**92.5%**	**Very Practical**

The results show that the e-book obtained an average practicality score of 92.35%, indicating that it is very practical for classroom use. The teacher reported that the e-book was easy to operate, systematically organized, and capable of supporting the implementation of Ethno-STEAM learning without requiring additional technical training. The integration of learning objectives, interactive activities, reflective questions, and digital assessments also simplified lesson preparation and classroom management. These findings are supported by (Hakim, 2020), who stated that interactive e-books can increase students' learning interest and engagement due to their flexibility and ease of use. Furthermore, digital learning media that are user-friendly and engaging tend to promote active participation in the learning process (Bond et al., 2020).

Similarly, students responded positively to the e-book because of its attractive visual design, simple navigation, and contextual learning activities. Most students stated that the multimedia features,

including authentic images, instructional videos, and interactive quizzes, helped them understand the learning materials more easily and encouraged them to participate actively during classroom activities. The contextual examples based on environmental issues in Bungurasih also enabled students to relate abstract scientific concepts to their daily experiences, making learning more meaningful.

These findings indicate that the practicality of the e-book extends beyond technical usability to include pedagogical effectiveness. The interactive multimedia design facilitates active engagement while supporting students' independent learning through reflective tasks and self-assessment activities. This result is consistent with previous studies showing that user-friendly digital learning media can improve students' motivation, participation, and learning engagement. Consequently, the developed Ethno-STEAM e-book can be considered a practical instructional medium that effectively supports student-centered learning and the development of critical thinking skills in elementary education

3.4 Effectiveness (Improvement of Critical Thinking Skills)

The effectiveness of the Ethno-STEAM-based e-book was determined by comparing students' critical thinking skills before and after the implementation of the learning media. Students completed a pre-test prior to the learning intervention and a post-test after using the e-book. The improvement in learning outcomes was further analyzed using the N-Gain test and a paired sample t-test. The results are presented in Table 3.3.

Table 3.3 Effectiveness Results

Critical Thinking Indicator	Pre-test	Post-test	N-Gain	Category
Problem Formulation	58	82	0.57	Moderate
Information Evaluation	55	80	0.56	Moderate
Drawing Conclusions	52	85	0.69	Moderate–High
Average	**55**	**82.3**	**0.61**	**Moderate**

The findings demonstrate a substantial improvement in students' critical thinking skills following the implementation of the Ethno-STEAM-based e-book. The mean score increased from 58.47 on the pre-test to 80.77 on the post-test, while the N-Gain value of 0.54 indicates a moderate level of improvement. Moreover, the paired sample t-test produced a significance value of 0.000 ($p < 0.05$), confirming that the difference between the pre-test and post-test scores was statistically significant. These findings are in line with Dewi et al. (2023), who found that interactive e-books based on problem-based learning significantly improve students' critical thinking skills. The improvement suggests that contextual and interactive learning environments can stimulate higher-order thinking processes (Zubaidah, 2020).

3.5 Discussion

The findings of this study indicate that the Ethno-STEAM-based e-book has significant effectiveness in improving elementary school students' critical thinking skills. This is evidenced by the N-Gain score of 0.61, which falls into the moderate to high category. This result suggests that learning media designed with contextual and interactive approaches can positively impact students' abilities in problem formulation, information evaluation, and logical conclusion drawing.

From a pedagogical perspective, the effectiveness of the e-book is influenced by the contextual learning approach applied. The learning materials are not presented as abstract concepts but are directly linked to real environmental issues in Bungurasih, such as waste management and water stagnation problems. This approach encourages students to analyze real-life phenomena, allowing their thinking processes to move beyond basic understanding toward higher levels of analysis and evaluation. This finding is consistent with constructivist theory, which emphasizes that knowledge is

more meaningful when constructed through direct experience and interaction with the environment (Mayer, 2020).

Furthermore, the integration of the Ethno-STEAM approach contributes significantly to the development of critical thinking skills. Through this approach, students not only learn scientific concepts but also relate them to technology, engineering, arts, and mathematics within a local cultural context. This integrative process enables students to view problems from multiple perspectives, thereby enhancing their analytical and evaluative abilities (Thibaut et al., 2020).

From the media perspective, the interactivity of the e-book plays a crucial role in supporting the improvement of critical thinking skills. Multimedia features such as images, videos, quizzes, and reflective activities provide varied and engaging learning experiences. Students are not merely passive recipients of information but actively participate in the learning process. This interaction encourages them to ask questions, evaluate information, and test their understanding independently (Mayer, 2020).

The findings of this study are also supported by previous research. Artiwi et al. (2020) found that e-books can enhance students' critical thinking skills through analytical and evaluative tasks. Ratnasari (2020) reported that interactive e-books increase student engagement, which positively affects critical thinking development. In addition, Andriani et al. (2021) demonstrated that e-books developed using the ADDIE model have high validity and practicality and effectively improve learning outcomes.

The novelty of this study lies in the integration of digital e-books, the Ethno-STEAM approach, and local cultural contexts into a single comprehensive learning design. Unlike previous studies that tend to examine e-books or STEAM separately, this study combines both elements into a contextual and culturally based learning medium. This integration not only enhances conceptual understanding but also fosters students' cultural and environmental awareness.

Overall, the results indicate that the Ethno-STEAM-based e-book is an effective instructional innovation for improving elementary students' critical thinking skills. The media creates an interactive, contextual, and meaningful learning environment, enabling students to develop higher-order thinking skills optimally. Therefore, the use of Ethno-STEAM-based e-books can serve as an alternative solution to overcome the limitations of conventional learning and support the implementation of 21st-century learning focused on higher-order thinking skills (HOTS).

4. CONCLUSION

This study developed and evaluated an Ethno-STEAM-based interactive e-book integrating Bungurasih local wisdom to improve elementary school students' critical thinking skills in Natural and Social Sciences (IPAS) learning. Developed using the ADDIE model, the e-book successfully integrated scientific concepts, digital technology, engineering activities, arts, mathematics, and authentic local environmental contexts into a unified digital learning environment. The findings demonstrated that the developed product fulfilled the criteria of a high-quality instructional medium. Expert validation indicated that the e-book was highly valid (91.7%), while teacher and student responses confirmed that it was highly practical for classroom implementation (92.5%). Furthermore, the effectiveness evaluation showed a statistically significant improvement in students' critical thinking skills, with an average N-Gain score of 0.61, indicating a moderate improvement after the learning intervention.

These findings suggest that integrating local wisdom into digital learning through the Ethno-STEAM approach creates meaningful and contextual learning experiences that support the development of higher-order thinking skills. Rather than functioning solely as a digital learning resource, the e-book served as a pedagogical tool that enabled students to investigate authentic environmental problems, construct evidence-based arguments, evaluate alternative solutions, and connect scientific knowledge with cultural values and everyday experiences. This study therefore contributes to the growing body of literature on culturally responsive digital pedagogy by demonstrating that indigenous knowledge can function as an epistemological foundation for science learning within technology-enhanced environments.

The novelty of this research lies in the comprehensive integration of interactive digital media, the Ethno-STEAM framework, Bungurasih local wisdom, and authentic environmental issues into a single

instructional design specifically intended to foster critical thinking among elementary school students. This integrated approach extends previous studies that have examined digital learning media, STEAM education, or ethnoscience separately and offers empirical evidence supporting the concept of Digital Ethno-Pedagogy as an innovative framework for twenty-first-century science education.

Despite these promising findings, this study has several limitations. The implementation involved only one class from a single elementary school using a one-group pretest–posttest design without a comparison group, which limits the generalizability of the findings and the ability to attribute learning gains exclusively to the intervention. Future research is therefore recommended to employ quasi-experimental or randomized controlled designs with larger and more diverse samples across different regions and cultural settings. Further studies may also investigate the long-term effects of Ethno-STEAM digital learning on students' critical thinking, creativity, environmental literacy, collaboration, and other twenty-first-century competencies while exploring the integration of various forms of local wisdom into digital science education.

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