Development of STEM-Based Science Learning Integrating Local Wisdom through Interactive Pop-Up Book in Elementary Schools

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Abstract

This study aims to develop STEM-based science learning devices integrated with Madurese local wisdom through interactive pop-up book media for elementary school students. The background of this study is the limited use of contextual learning resources and innovative media in elementary science instruction, which affects students' engagement and conceptual understanding. This research employed a Research and Development (R&D) method using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The developed learning devices included teaching modules, interactive pop-up books, student worksheets, and assessment instruments. The validation results from material experts, media experts, and learning experts indicated that the learning devices were highly valid. Student responses showed a very positive perception of the learning process, and learning outcomes improved after the implementation of the developed devices. The integration of STEM principles with Madurese local wisdom—such as coastal ecosystems, salt production, and fishermen's activities—made science learning more meaningful and contextual. Therefore, the developed STEM-based science learning devices integrated with local wisdom are feasible and effective for use in elementary school science learning.

Keywords – Science Education, STEM, Local Wisdom, Pop-Up Book, Elementary School

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1. Introduction

Science education in elementary schools serves as the fundamental cornerstone for developing scientific literacy, fostering curiosity, and honing problem-solving skills from an early age. However, a significant gap remains between ideal pedagogical goals and classroom reality. Current science instruction is frequently hindered by conventional methodologies that rely heavily on static textbooks and teacher-centered approaches. According to Elkordy (2016), this lack of innovation leads to low student engagement and a superficial understanding of core concepts. Without a shift toward more dynamic instruction, students struggle to see the relevance of science in their lives. Therefore, there is an urgent need to develop instructional tools that move beyond rote memorization toward active, inquiry-based exploration.

To address these instructional deficiencies, the STEM (Science, Technology, Engineering, and Mathematics) approach offers a robust framework by emphasizing interdisciplinary integration. This methodology is designed to cultivate essential 21st-century skills, including critical thinking, creativity, collaboration, and communication (Imaduddin et al., 2020; Rizaldi et al., 2020). STEM-based learning shifts the classroom dynamic by encouraging students to apply abstract scientific principles to tangible, real-world problems through inquiry and design-based activities. By positioning students as active problem-solvers who must engineer solutions, the STEM approach transforms science from a collection of facts into a functional tool for innovation and discovery.

In addition to global pedagogical trends like STEM, incorporating local wisdom into the curriculum is vital for enhancing contextual understanding and cultural relevance. Local wisdom represents the collective knowledge, values, and practices developed by communities through centuries of interaction with their environment (Indriani et al., 2019). In the specific context of Madura, indigenous practices such as traditional salt farming, the management of coastal ecosystems, and the logistical livelihoods of local fishermen provide a rich, untapped laboratory for elementary science learning. Integrating these local elements

ensures that science is not perceived as a foreign concept but as a reflection of the students' own socio-cultural reality, making the learning process more meaningful and grounded.

While previous studies have explored the benefits of STEM and the importance of ethnoscience separately, there is a noticeable gap in the literature regarding the synthesis of these two elements into a single, interactive learning medium for primary education. Many existing STEM modules remain abstract or detached from the students' immediate cultural environment. This research addresses that gap by merging the rigorous framework of STEM with the specific cultural nuances of Madurese local wisdom. The novelty of this study lies in its "hybridization" of modern scientific inquiry with traditional local practices, providing a unique stance that supports and extends previous research on culturally responsive pedagogy. By doing so, this study creates a bridge between global scientific standards and local cultural identity.

The effectiveness of these integrated concepts relies heavily on the quality of the delivery medium. Interactive pop-up books offer a unique pedagogical advantage by providing three-dimensional visualization and hands-on interaction, which are essential for students in the concrete operational stage of development. This tactile engagement can significantly improve motivation and comprehension, particularly for abstract science concepts that are difficult to grasp through 2D illustrations. Consequently, the primary objective of this study is to develop STEM-based science learning devices that integrate Madurese local wisdom through interactive pop-up book media. Furthermore, this research aims to rigorously examine the validity, practicality, and effectiveness of these devices in an elementary school setting to ensure they meet both academic and pedagogical standards.

2. Method

This study employed a Research and Development (R&D) approach using the ADDIE development model, which includes five stages: analysis, design, development, implementation, and evaluation (Branch, 2009).

a. Analysis Stage

The analysis stage involved needs analysis, curriculum analysis, and learner characteristic analysis. Needs analysis was conducted through classroom observations and interviews with elementary school teachers in Bangkalan Regency, Madura, to identify problems in science learning and potential local wisdom integration.

b. Design Stage

At the design stage, STEM-based science learning devices integrated with Madurese local wisdom were designed. The learning materials incorporated contexts such as coastal ecosystems, salt production processes, and fishermen's activities. The interactive pop-up book was designed to support visualization and hands-on learning activities.

c. Development Stage

The development stage involved producing the learning devices and conducting expert validation. Validation was carried out by material experts, media experts, and learning experts using Likert-scale validation instruments. Revisions were made based on expert feedback.

d. Implementation Stage

The revised learning devices were implemented in a limited trial involving fifth-grade elementary school students in Madura. Data on student responses and learning outcomes were collected during this stage.

e. Evaluation Stage

The evaluation stage aimed to determine the validity, practicality, and effectiveness of the developed learning devices.

3. Result and Discussion

To examine the effectiveness of the developed learning devices, a pretest–posttest design was employed. Students were given a pretest before the implementation of the STEM-based learning devices and a posttest after the learning activities (Rusnilawati et al., 2023).

Table 1. Pretest–Posttest Results and N-Gain Score

Assessment	Mean Score	Minimum	Maximum
Pretest	56.40	40	70
Posttest	82.30	70	95

The improvement in learning outcomes was further analyzed using the normalized gain (N-gain) formula. The average N-gain score obtained was 0.60, which falls into the moderate improvement category. This result indicates that the developed STEM-based science learning devices are effective in improving students' conceptual understanding.

Expert Validation Results

The expert validation results indicated that the developed learning devices were highly valid. The material aspect was aligned with the elementary science curriculum and students' cognitive levels (Imaduddin et al., 2020; Rusnilawati et al., 2023).

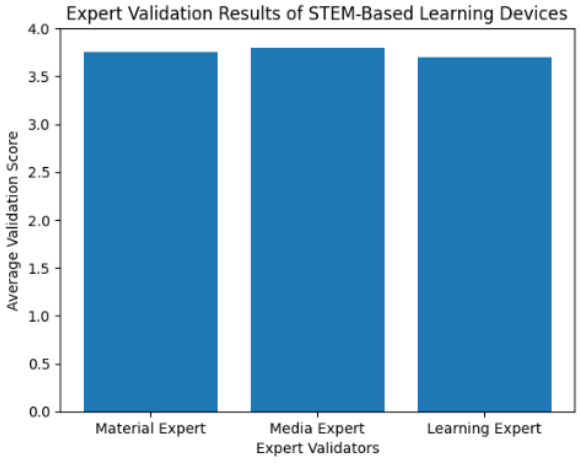


Figure 1. Expert Validation Result



Figure 2. Pop-up book

The media aspect showed that the interactive pop-up book was visually attractive, easy to use, and effective in illustrating science concepts. The integration of STEM principles with Madurese local wisdom through interactive pop-up book media provides meaningful and contextual learning experiences. Unlike previous studies that examined STEM learning or local wisdom separately, this study combines both elements within a single learning device, particularly for elementary science education.

Student Responses

Student responses to the use of the interactive pop-up book were very positive. Students reported increased interest and enjoyment in learning science because the materials were closely related to their daily lives in Madura, such as salt farming and coastal activities (Hadi et al., 2019; Yuwono et al., n.d.). This integration helps students connect scientific concepts with real-life phenomena and cultural practices, thereby enhancing learning relevance and engagement (Rizaldi et al., 2020).

4. Conclusion

The STEM-based science learning devices integrating Madurese local wisdom through interactive pop-up book media are valid, practical, and effective for elementary school science learning. The use of local contexts such as coastal ecosystems and salt production enhances students' engagement and understanding of science concepts. Future research is recommended to

implement the learning devices on a larger scale and across different science topics.

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