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Development of a Local-Content-Based Interactive Science E-Book in Chemistry Education: Matter and Its Changes Material to Enhance Elementary School Students' Science Literacy

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Abstract: Developing students' scientific literacy requires learning resources that are interactive, contextual, and relevant to their cultural environment. This study aimed to develop and evaluate a local-content-based interactive science e-book on the topic of matter and its changes for elementary school students. This study employed a Research and Development approach involving expert validation and classroom implementation at MIN 4 Banda Aceh. The developed e-book was evaluated by material and media experts, followed by implementation with fourth-grade students. Data were analyzed using descriptive quantitative analysis to determine the feasibility of the e-book and students' scientific literacy across five dimensions. The e-book obtained highly appropriate ratings from media experts (90%) and material experts (91%), indicating that it met the feasibility criteria for classroom use. During classroom implementation, students achieved an overall scientific literacy score of 78.9% (high category). The highest achievement was observed in scientific content knowledge (89.4%) and scientific attitude (81.9%), while comparatively lower scores in scientific process, reasoning, and application in real-world contexts indicate areas requiring further instructional support. The findings suggest that the developed interactive science e-book is a feasible learning resource that supports contextual science learning and the development of students' scientific literacy through the integration of Acehnese local content.

Keywords: Acehnese local content; Elementary school; Interactive science e-book; Matter and its changes; Scientific literacy

Introduction

Rapid advances in science and technology have transformed the competencies required for learners in the twenty-first century. Among these competencies, scientific literacy has become essential because it enables students to understand scientific concepts, evaluate evidence, solve real-world problems, and make informed decisions in their daily lives (Pratiwi et al., 2019; Safitri et al., 2023). Developing scientific literacy from the elementary school level is particularly important because this stage establishes the foundation for higher-order thinking, scientific reasoning, and lifelong learning (Sari & Amini, 2020).

Despite its importance, Indonesian students continue to demonstrate low levels of scientific literacy. According to the Programme for International Student Assessment (PISA) 2022, Indonesia ranked 71st among 79 participating countries, with an average science score of only 366, substantially below the OECD average of 472 (OECD, 2022). These findings indicate that many students still experience difficulties in understanding scientific concepts and applying scientific knowledge to everyday situations. This persistent gap suggests that conventional science instruction has not yet adequately supported the development of scientific literacy, highlighting the need for more contextual and engaging learning approaches, particularly at the elementary

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school level. Elementary school represents a critical stage for strengthening scientific literacy because students begin to develop conceptual understanding through direct experiences and contextual learning. At this level, learning resources should not only deliver scientific knowledge but also encourage students to relate scientific concepts to familiar situations. Therefore, innovative learning media that actively engage students are required to bridge abstract scientific concepts with their everyday experiences.

One of the fundamental science topics introduced in elementary school is matter and its changes. This topic was selected because it contains abstract concepts that students often find difficult to understand through conventional textbook-based instruction. At the same time, the concepts are closely connected with everyday phenomena, such as melting ice, boiling water, evaporation, and food preparation. Consequently, this topic provides an appropriate context for developing students' scientific literacy by linking scientific explanations with real-life experiences.

In response to these issues, it is necessary to employ learning strategies that can enhance students' engagement and understanding of scientific concepts contextually. One potential alternative is the use of interactive learning media based on science literacy. Interactive media can serve as a virtual laboratory to improve science process skills (Sari et al., 2015). Previous studies have demonstrated that digital learning media, including interactive e-books, e-modules, and multimedia applications, can improve students' conceptual understanding and scientific literacy by providing interactive visualizations and self-directed learning opportunities (Latip & Faisal, 2021; Suryati et al., 2021). However, most existing studies have primarily emphasized technological features while paying limited attention to the integration of local contexts that are familiar to elementary school students. The development of contextual media enables practical learning and enhances science literacy (Akbar et al., 2023). In a broader context, research shows that challenges in science literacy persist in Indonesia, and there is a need for well-designed strategies as well as innovative media to address these issues (Nisa et al., 2021).

The use of e-books in science education has been proven to enhance students' science literacy, particularly at the elementary and secondary education levels. Several studies indicate that e-books, as interactive learning media, provide broader access to scientific information and facilitate more engaging learning approaches for students. One study by Lyla et al. (2022) developed an e-book learning medium specifically designed for children aged 4–5 years, focusing on science. The results demonstrated that the e-book not only captured students' attention but also increased their learning motivation. This finding is consistent with the analysis by Latip and Faisal, who emphasized that computer-based media, including e-books, positively contribute to improving science literacy (Nasution et al., 2025; Nurohman et al., 2025; Sugianto et al., 2023).

Integrating local content into science learning can make scientific concepts more meaningful because students learn through examples, phenomena, and cultural practices that they encounter in their own environment. Local-context learning also supports contextual understanding, increases learning motivation, and strengthens students' ability to connect scientific knowledge with everyday life (Harefa, 2024; Sarawati & Natadiwijaya, 2025). Nevertheless, studies examining interactive science e-books that integrate both scientific literacy and local content for elementary chemistry education remain limited.

Unlike previous studies that mainly focused on developing interactive digital media or science literacy independently, this study integrates three complementary aspects into a single learning resource: (1) an interactive e-book format, (2) science literacy-oriented learning activities, and (3) Acehnese local content embedded within the topic of matter and its changes. This integration is expected to create a more contextual learning experience by connecting abstract chemistry concepts with students' cultural and everyday environments while simultaneously strengthening their scientific literacy.

Based on these considerations, this study aims to develop and evaluate a local-content-based interactive science e-book on the topic of matter and its changes for elementary school students. Specifically, this study examines the feasibility of the developed e-book and its students' scientific literacy performance. The findings are expected to provide an innovative learning resource that supports contextual science learning while contributing empirical evidence regarding the integration of local culture into digital science education.

Method

This study employed a Research and Development (R&D) approach using the Borg and Gall development model to design, validate, and evaluate a local-content-based interactive science e-book. The Borg and Gall model was selected because it provides a systematic framework for developing educational products through iterative stages of needs assessment, product development, expert validation, revision, and field testing (Setyowati et al., 2024; Wati & Wulansari, 2021). To accommodate the scope of this study, the original ten

stages were simplified into seven stages: (1) preliminary research and needs analysis, (2) planning, (3) initial product development, (4) expert validation and limited trial, (5) product revision, (6) main field testing, and (7) final product revision.

The overall research procedure followed the modified Borg and Gall development model. The stages implemented in this study are illustrated in Figure 1.

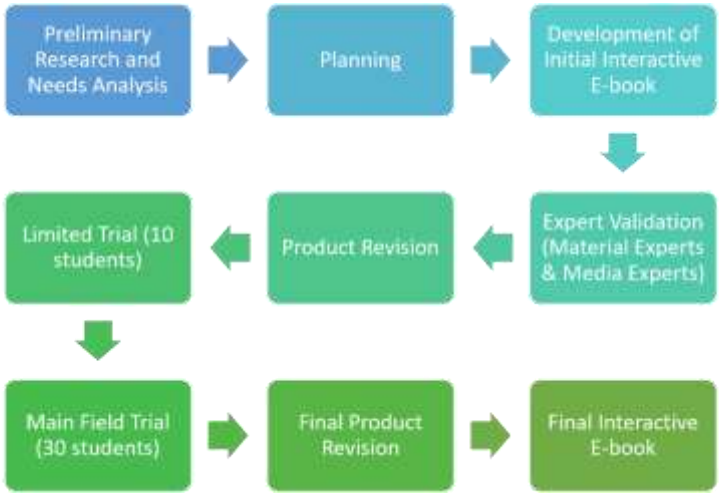

Figure 1. Research Procedure Based on the Borg and Gall Development Model

As shown in Figure 1, the study began with a preliminary needs analysis to identify problems in science learning and students' scientific literacy. The information obtained was used to develop the initial prototype of the local-content-based interactive e-book, which was subsequently validated by experts, revised, tested with students, and refined into the final product.

The study was conducted at MIN 4 Banda Aceh during the 2024/2025 academic year. Different participants were involved at each stage of the development process. Product validation involved four validators, consisting of two material experts (one science education lecturer and one Grade IV classroom teacher) and two media experts (one educational technology lecturer and one elementary education lecturer). The limited trial involved 10 fourth-grade students to obtain initial feedback on the usability of the e-book. Subsequently, the main field trial involved 30 fourth-grade students, who participated in the implementation of the developed e-book to evaluate its practicality in implementation scientific literacy.

Three research instruments were employed. First, material validation sheets were used to evaluate the accuracy, relevance, completeness, and curriculum alignment of the e-book content. Second, media validation sheets assessed the quality of interface design, navigation, interactivity, visual presentation, and usability. Third, a scientific literacy observation instrument was used during classroom implementation to assess students' scientific literacy across five dimensions: scientific content knowledge, scientific process, reasoning, application in real-world contexts, and scientific attitude.

The data analysis technique employed was quantitative descriptive analysis, which was used to assess the feasibility of the interactive e-book. The validity assessment was carried out by material experts and media experts. The validation results obtained from these experts were used to determine the feasibility of the developed e-book. The feasibility of the developed e-book was determined using descriptive quantitative analysis. Scores provided by expert validators were converted into percentages using the equation 1.

$$\text{Percentage} = \frac{\sum X}{N \times X_{mks}} \times 100\ \% \quad (1)$$

Description:
$\sum X$: Total score obtained
N : Number of assessors (validators)
X_{maks} : Maximum score for each item

The percentage results were interpreted according to the feasibility criteria presented in Table 1.

Table 1. Criteria for Evaluating the Feasibility of the Interactive E-book (Riduwan, 2011)

Interval (percentage)	Categories
81 – 100	Highly appropriate
61 – 80	Appropriate
41 – 60	Moderately appropriate
21 – 40	Less appropriate
0 – 20	Not appropriate

Students' scientific literacy data obtained from classroom observations were analyzed descriptively by calculating the percentage score for each scientific literacy dimension. The overall literacy score was then classified into five categories: very high, high, moderate, low, and very low, as presented in Table 2.

Table 2. Criteria for Classifying Students' Scientific Literacy (Riduwan, 2011)

Interval (percentage)	Categories
81 – 100	Very High
61 – 80	High
41 – 60	Moderate
21 – 40	Low
0 – 20	Very Low

Result and Discussion

The results are presented according to the stages of product evaluation, consisting of (1) expert validation, (2) limited field trial, and (3) main field trial. These stages were conducted to evaluate the feasibility of the developed interactive science e-book and to investigate students' scientific literacy during its implementation. The results of the development research on the interactive science e-book were obtained based on assessments from media experts and material experts. The assessment results from the media experts are presented in Table 3.

Table 3. Media Expert Validation

Assessment Aspects	Expert 1	Expert 2	Percentage (%)	Categories
The e-book design is attractive and developmentally appropriate for the target age group	5	4	90	Highly appropriate
The use of illustrations effectively facilitates comprehension	4	5	90	Highly appropriate
The navigation and interactivity are user-friendly and facilitate ease of use	4	5	90	Highly appropriate
Consistency in layout and color usage	4	4	80	Highly appropriate
The alignment of the media with the Acehnese cultural context	5	4	90	Highly appropriate

The media validation score of 90% indicates that the developed e-book possesses a high level of usability and visual quality. The highest ratings were obtained for the design attractiveness, illustration quality, navigation, and integration of Acehnese cultural contexts. These findings suggest that embedding local contexts into digital learning resources makes science concepts more familiar and meaningful for elementary students. This result supports Akbar et al. (2023), who argued that contextual learning media facilitate meaningful science learning by connecting scientific concepts with students' everyday experiences. Likewise, the high score for interactivity demonstrates that multimedia elements such as animations, illustrations, and interactive navigation can increase learner engagement. Previous studies by Latip and Faisal (2021) similarly reported that interactive digital media significantly improve students' motivation and conceptual understanding.

Furthermore, the assessment was carried out by two material experts, consisting of a classroom teacher and a science education lecturer. The results of the assessment are presented in Table 4.

Table 4. Material Expert Validation

Assessment Aspects	Expert 1	Expert 2	Percentage (%)	Category
A. Content Alignment with Competencies				
The material is in accordance with the indicators in the Merdeka Curriculum	4	4	100	Highly appropriate
The level of depth and breadth of the material is appropriate to the students' developmental stage	4	3	87.5	Highly appropriate
The Relevance of the material to the local context and everyday life	4	4	100	Highly appropriate
B. Language and Presentation of Concepts				
The scientific concepts presented are scientifically accurate.	4	4	100	Highly appropriate
Examples and illustrations appropriately support concept comprehension.	3	4	87.5	Highly appropriate
C. Material Actualization				

Assessment Aspects	Expert 1	Expert 2	Percentage (%)	Category
The material presented is up to date and aligned with the development of science and technology	4	3	87.5	Highly appropriate
D. Language and Presentation				
The language used is appropriate for the students' developmental level.	4	3	87.5	Highly appropriate
The sentences are effective and easy to understand.	3	4	87.5	Highly appropriate

The research findings show that the average score on the indicator of content alignment with competencies is 95.8% in the highly appropriate category; the indicator of language and concept presentation is 93.7% in the highly appropriate category; the indicator of material actualization is 87.5% in the highly appropriate category; and the indicator of language and presentation obtained an average score of 87.5% in the highly appropriate category. Overall, the material experts' assessment of the developed e-book obtained an average score of 91% in the highly appropriate category. This indicates that the locally integrated interactive e-book meets the feasibility criteria for use in science learning based on chemistry education at the elementary school level.

The revised e-book was initially implemented with ten fourth-grade students to identify usability issues before the main field trial. Overall, students responded positively to the interactive features and local-context illustrations. Minor revisions suggested during this stage included increasing font size, simplifying several instructions, and improving the contrast of navigation buttons. After revisions were completed, the e-book was implemented in the main field trial involving 30 fourth-grade students. Students' scientific literacy was observed across five dimensions. The results of the observation on the use of the e-book product are as follows Table 5.

Table 5. Science literacy observation data

Science literacy dimensions	Actual Score	Maximum Score	Percentage (%)
Scientific Content Knowledge	322	360	89.4
Scientific Process	255	360	70.8
Reasoning	268	360	74.4
Application in Real World Contexts	280	360	77.8
Scientific Attitude	295	360	81.9

The highest achievement was found in scientific content knowledge (89.4%). This indicates that the integration of interactive explanations and local examples effectively facilitated students' understanding of abstract concepts related to matter and its changes. According to OECD (2019), conceptual understanding is the fundamental dimension of scientific literacy because it enables learners to explain scientific phenomena and make evidence-based decisions. Scientific attitude also reached a very high category (81.9%), suggesting that contextual learning through Acehnese local examples stimulated students' curiosity and interest in science. This finding is consistent with Gormally et al. (2012), who emphasized that contextual science learning promotes positive scientific attitudes and critical thinking. Although scientific process and reasoning obtained comparatively lower scores, both remained within the high category. This finding indicates that students still require greater opportunities to conduct investigations, interpret evidence, and formulate conclusions. Similar findings were reported by Suryati et al. (2021), who found that interactive media alone are insufficient unless accompanied by inquiry-based activities.

The findings of this study are consistent with previous research demonstrating that interactive digital learning media can improve students' understanding of science concepts and support the development of scientific literacy. The expert validation results, which indicated that the developed e-book achieved highly appropriate categories in both media (90%) and content (91%) aspects, confirm that integrating multimedia features into science learning enhances the quality of instructional materials. Similar findings were reported by Latip & Faisal (2021), who concluded that computer-based learning media, including interactive e-books and digital modules, facilitate students' conceptual understanding by providing visualizations, interactive navigation, and immediate learning feedback. Likewise, Suryati et al. (2021) found that interactive e-modules significantly improved students' scientific literacy because multimedia elements increased learners' engagement and conceptual comprehension.

The implementation results also revealed that students achieved a high level of scientific literacy, with an overall score of 78.9%. The highest achievement was observed in the dimension of scientific content knowledge (89.4%), followed by scientific attitude (81.9%). These findings support the work of Gormally et al. (2012), who emphasized that scientific literacy-oriented learning contributes not only to conceptual understanding but also to students' ability to interpret

scientific information and develop positive attitudes toward science. Similarly, OECD (2019) highlights that mastering scientific concepts constitutes the foundation for applying scientific reasoning to real-world problems. The high achievement in these two dimensions suggests that presenting scientific concepts through contextual and interactive learning resources enables elementary school students to connect classroom learning with everyday experiences more effectively (Glynn & Winter, 2004).

Compared with previous studies, the present research offers an important contribution by integrating interactive digital technology, scientific literacy principles, and Acehnese local content into a single instructional resource. Previous studies by Andaresta (2021) primarily focused on STEM-based e-books, while Lyla et al. (2022) emphasized the role of e-books in increasing young children's motivation to learn science. Although these studies demonstrated the educational benefits of digital learning media, they provided limited attention to the incorporation of local cultural contexts as a strategy for strengthening scientific literacy. In contrast, the interactive e-book developed in this study embeds examples, illustrations, and learning activities derived from students' local environment, enabling learners to understand abstract concepts of matter and its changes through familiar cultural experiences.

Furthermore, the integration of Acehnese local content represents the main novelty of this study. Contextual examples related to students' daily lives make scientific concepts more meaningful and easier to comprehend while simultaneously preserving local cultural values within science education. This finding supports the contextual learning theory proposed by Akbar et al. (2023), which argues that connecting learning materials with students' social and cultural environments promotes deeper conceptual understanding and more meaningful learning experiences. Therefore, this study extends previous literature by demonstrating that the combination of interactive learning media, scientific literacy-oriented instruction, and local cultural integration can serve as a promising approach for improving the quality of elementary science education.

Despite these positive findings, the dimensions of scientific process (70.8%) and scientific reasoning (74.4%) obtained comparatively lower scores than content knowledge and scientific attitude. This result indicates that although interactive learning media effectively support conceptual understanding, students still require more opportunities to conduct investigations, analyze evidence, and formulate scientific explanations. Similar observations were reported by Suryati et al. (2021), who suggested that digital learning media should be complemented with inquiry-based or experiment-oriented activities to optimize the development of higher-order scientific literacy skills. Consequently, future development of the e-book should incorporate guided experiments, problem-based investigations, and collaborative scientific discussions to strengthen students' scientific reasoning and inquiry competencies.

Unlike previous studies that primarily developed digital learning media without incorporating local contexts, the present study demonstrates that integrating Acehnese local content into an interactive science e-book can support both conceptual understanding and students' scientific literacy. This finding contributes to the growing body of literature on contextual science education by highlighting the role of local culture in enhancing meaningful learning.

Conclusion

This study developed a local-content-based interactive science e-book on the topic of matter and its changes for elementary school science learning. The expert validation results indicated that the developed e-book met the criteria for high feasibility in terms of both content and media quality, suggesting that it is appropriate for classroom implementation. The field implementation further showed that students demonstrated a high level of scientific literacy, particularly in the dimensions of scientific content knowledge and scientific attitude. However, comparatively lower scores in the dimensions of scientific process and scientific reasoning indicate that students still require greater opportunities to engage in inquiry-based and evidence-based learning activities. Therefore, future development of the e-book should incorporate more investigation-oriented tasks and experimental activities to strengthen these competencies. Overall, the findings suggest that integrating interactive digital learning resources with Acehnese local content provides a promising approach to supporting contextual science learning in elementary schools. This study was limited to implementation in one elementary school without a comparative experimental design. Future studies are therefore encouraged to involve larger samples and experimental approaches to examine the impact of the developed e-book on students' scientific literacy more comprehensively.

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