

Needs Analysis and Prototype Design of an Education for Sustainable Development-Based Digital Application for Elementary School Reading Literacy

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Abstract

Elementary school students continue to face literacy challenges, particularly in reading comprehension, identifying main ideas, interpreting information, and connecting texts with everyday contexts. This study aimed to analyze students' literacy conditions and the integration of Education for Sustainable Development (ESD) in learning as a basis for developing an ESD-based digital literacy application for elementary school students. A qualitative descriptive approach supported by simple quantitative data was employed. Participants comprised 30 fourth-grade students selected through purposive sampling. Data were collected through observations, teacher interviews, documentation, and questionnaires and analyzed using qualitative data reduction, data presentation, conclusion drawing, and descriptive percentages. The findings revealed relatively low to moderate literacy performance, with scores of 58% for reading comprehension, 54% for identifying main ideas, 56% for text interpretation, 52% for connecting texts with everyday life, and 60% for reflection on reading. ESD-related indicators showed environmental awareness at 70%, sustainable behavior at 63%, and social collaboration at 72%. Based on the identified needs, an ESD-based digital literacy application was developed by integrating contextual digital reading materials, interactive quizzes, educational videos, reflective activities, and sustainability content encompassing environmental, social, and economic dimensions. The findings demonstrate the need for digital learning resources that integrate literacy development with sustainability-oriented contexts and provide an empirical basis for the application's development. Further experimental evaluation is required to determine its effectiveness in improving students' literacy and sustainability competencies.

Keywords: Digital literacy, Education for Sustainable Development, Elementary education, Literacy application, Sustainability education.

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I. INTRODUCTION

Reading literacy is a fundamental competency that enables students to understand information, construct knowledge, and apply what they have learned across various situations in everyday life. In elementary education, reading literacy extends beyond the literal comprehension of written texts. It involves locating relevant information, identifying main ideas, interpreting meaning, connecting information across texts and personal experiences, and reflecting on what has been read. These competencies have become increasingly important as contemporary learning requires students to think critically, engage with diverse forms of information, and apply their understanding meaningfully in real-life contexts.

Literacy remains a considerable educational challenge in Indonesia, as reflected in the Programme for International Student Assessment (PISA) 2022 results. Indonesia recorded an average reading score of 359, declining from 371 in PISA 2018. Only approximately 25% of Indonesian students achieved at least Level 2 proficiency in reading, compared with an OECD average of 74%. At this level, students are expected to demonstrate basic competencies such as identifying the main idea of a text, locating information based on specified criteria, and reflecting on the purpose or form of a text. Although PISA assesses 15-year-old students and therefore cannot be interpreted as direct evidence of elementary school students' reading proficiency, these findings underscore the importance of establishing strong literacy foundations from the early stages of education.

This need was also evident in the context of the present study. An initial analysis involving 30 fourth-grade students showed that achievement across several dimensions of reading literacy remained relatively low to moderate. Students achieved 58% in reading comprehension, 54% in identifying main ideas, 56% in interpreting texts, 52% in connecting textual information with everyday life, and 60% in reflecting on reading content. These findings suggest that students'

difficulties extend beyond retrieving literal information and are particularly evident in meaning construction and the contextual application of information. Accordingly, the learning need identified in this study is more appropriately conceptualized as the development of reading literacy, whereas digital technology serves as a learning medium rather than as a separate digital literacy construct to be measured.

Reading literacy can be meaningfully integrated with Education for Sustainable Development (ESD) so that reading activities extend beyond textual comprehension and encourage students to engage with authentic issues in their social and environmental contexts. UNESCO conceptualizes ESD as an educational approach that equips learners with the knowledge, skills, values, attitudes, and capacities needed to make informed decisions and act responsibly in relation to environmental, social, and economic challenges. ESD encompasses cross-cutting competencies such as systems thinking, anticipatory competence, normative competence, strategic competence, collaboration, critical thinking, self-awareness, and integrated problem-solving. These competencies should be developed in ways appropriate to learners' ages and developmental stages. At the elementary level, they can be translated into accessible learning activities that encourage students to recognize relationships between actions and their consequences, consider the implications of different choices, collaborate with others, justify decisions, and reflect on personal responsibility.

The initial findings of this study further indicated a need to strengthen ESD-related competencies. Students demonstrated environmental awareness at 70%, sustainable behavior at 63%, and social collaboration at 72%, with all three indicators categorized at a moderate level. These findings provide an opportunity to connect reading literacy activities with sustainability-oriented content. In this study, ESD integration is not limited to incorporating environmental themes into reading passages. Instead, it involves presenting situations in which students are encouraged to read, comprehend, interpret, consider consequences, and reflect on choices and actions within environmental, social, and economic sustainability contexts. Such an approach positions reading as a means of engaging with meaningful issues rather than merely as an exercise in extracting information from texts.

Digital applications offer one potential means of providing more varied and interactive literacy experiences; however, the use of technology does not inherently guarantee improved learning outcomes. Students' familiarity with smartphones should not be equated with readiness for digital learning. The development of digital learning media therefore needs to consider alignment between design and learning objectives, students' abilities, device and connectivity availability, teachers' digital competence, parental support, and opportunities for access outside school. Consequently, the application developed in this study is positioned as a digital learning medium supporting ESD-based reading literacy, rather than being based on the assumption that exposure to digital devices will automatically enhance students' literacy competencies.

From a pedagogical perspective, the design of digital learning media should also be grounded in mechanisms that explain how individual features contribute to learning. The Cognitive Theory of Multimedia Learning suggests that meaningful learning can be facilitated when verbal and visual information is presented in ways that account for the limited capacity of human information processing and encourage learners to actively select, organize, and integrate information. Based on these principles, the combination of text, illustrations, videos, and quizzes in the proposed application is intended to facilitate students' comprehension and organization of information rather than merely increase the variety of media presented. Similarly, points, badges, and levels are incorporated as gamification elements intended to support learning engagement. Nevertheless, the cognitive and motivational benefits of gamification depend on its design and context of implementation; therefore, its educational value requires empirical evaluation rather than being assumed.

Previous studies have examined digital literacy and technology use in elementary education (Pratiwi & Setyaningrum, 2022; Yulianti & Hartanto, 2021; Wijayanti et al., 2025), while other research has addressed the integration of ESD into elementary education (Sari & Mulyono, 2021). However, further research is needed to specifically use empirical evidence regarding students' reading literacy and ESD-related conditions as the basis for designing a digital application prototype that connects reading activities with sustainability contexts. Accordingly, the novelty of the present

study does not lie merely in the use of digital technology, but in employing empirically identified student needs to inform the design of a prototype that integrates reading literacy, ESD content, reflective activities, and interactive learning features.

At this stage, the study is not intended to establish the effectiveness of the application in improving students' literacy outcomes. Instead, it focuses on needs analysis and prototype development as a foundation for subsequent empirical evaluation. Accordingly, the study addresses three research questions: (1) What are the reading literacy conditions and ESD-related indicators of fourth-grade students that inform the need for application development? (2) What learning needs should be accommodated in an ESD-based digital application? and (3) What are the characteristics of an ESD-based digital application prototype designed in response to the identified needs? Based on these questions, this study aims to analyze students' reading literacy conditions and ESD-related indicators and to design an ESD-based digital application prototype that responds to the identified learning needs in elementary education.

II. METHOD

This study employed a qualitative descriptive approach supported by simple quantitative data to provide a comprehensive understanding of elementary school students' reading literacy conditions and to identify learning needs for the development of an Education for Sustainable Development (ESD)-based digital learning application. This approach was selected because the study was intended not only to describe students' literacy achievement but also to understand learning practices and needs within the authentic school context. The study involved 30 fourth-grade elementary school students selected through purposive sampling.

Data were collected through observation, interviews, documentation, and questionnaires. Observations were conducted to examine classroom learning activities, student engagement, and literacy-related behaviors during the learning process. Semi-structured interviews with the classroom teacher were used to obtain information regarding literacy instruction, instructional strategies, encountered challenges, and the use of learning media. Documentation was used to complement the data through instructional materials, students' learning records, and records of classroom activities. Questionnaires were administered to obtain descriptive quantitative data on students' reading literacy conditions and ESD-related indicators.

The research instruments consisted of an observation sheet, a semi-structured interview guide, and Likert-scale questionnaires. The reading literacy indicators included comprehension of reading content, identification of important information, interpretation of textual information, connection of reading content with real-life contexts, and reflection on reading. The ESD indicators comprised environmental awareness, sustainable behavior, and social collaboration in learning activities. The content validity of the questionnaires was assessed through expert judgment to ensure that the indicators adequately represented the constructs being examined.

Qualitative and quantitative data were analyzed in an integrated manner. Qualitative data were analyzed using the Miles and Huberman interactive model, involving data reduction, data display, and conclusion drawing or verification. Quantitative data were analyzed descriptively using percentages and achievement categories to characterize students' reading literacy and ESD-related conditions. The findings from both types of data were then integrated to identify the learning needs that informed the design of the ESD-based digital application prototype. Thus, the analysis served as a needs-analysis foundation for prototype development rather than as an evaluation of the application's effectiveness.

III. RESULTS AND DISCUSSION

A. Results

The findings are presented according to three interrelated areas: students' reading literacy conditions, the achievement of *Education for Sustainable Development* (ESD) indicators in learning, and the development of an ESD-based digital literacy application as a learning innovation. These areas were examined to provide an empirical overview of the existing conditions and to identify the need for learning media that are more contextual, interactive, and responsive to the characteristics of elementary school students in digital learning environments.

1. Students' Reading Literacy

The observation findings indicated that students' reading literacy generally remained at low to moderate levels. Some students experienced difficulties in comprehending reading texts, identifying main ideas, and interpreting textual information. Difficulties were also evident when students were required to connect information from texts with their everyday experiences. These findings indicate that students had not yet consistently developed the ability to construct deeper and more contextual meaning from reading materials.

School literacy activities had been implemented through regular reading sessions before classroom instruction and the provision of reading corners in each classroom. However, these activities had not yet resulted in sustained reading habits, particularly beyond the school environment. Students' literacy activities remained largely associated with formal school routines rather than becoming part of their everyday learning practices. To obtain a more detailed profile of students' reading literacy, five aspects were examined: reading comprehension, identification of main ideas, interpretation of texts, connection of reading content with everyday life, and reflection on reading content. The results are presented in Table 1.

Table 1. Students' Reading Literacy Results

No.	Reading Literacy Aspect	Percentage	Category
1	Reading comprehension	58%	Moderate
2	Identifying main ideas	54%	Low
3	Interpreting texts	56%	Moderate
4	Connecting reading content with everyday life	52%	Low
5	Reflection on reading content	60%	Moderate

As shown in Table 1, the lowest achievement was found in connecting reading content with everyday life (52%), followed by identifying main ideas (54%), both of which were categorized as low. Students' performance in interpreting texts (56%), reading comprehension (58%), and reflecting on reading content (60%) was categorized as moderate. Overall, these results indicate that students experienced greater difficulty in identifying essential meaning and applying textual information to real-life contexts than in general comprehension and reflection. These findings provided an empirical basis for identifying the literacy needs to be accommodated in the subsequent development of the ESD-based digital application.

2. ESD-Related Conditions

The observation findings showed that students had begun to demonstrate awareness of the importance of maintaining their school environment. This was reflected in behaviors such as disposing of waste appropriately, maintaining classroom cleanliness, and participating in collaborative activities at school. These observations indicate that sustainability-related values had been introduced through classroom learning and students' everyday school activities. However, sustainable behaviors were not consistently demonstrated in students' daily practices. Some students continued to use school facilities without sufficient consideration and were less likely to maintain cleanliness when direct teacher supervision was absent. These findings suggest that students' understanding and enactment of sustainability principles still require reinforcement through learning experiences that are contextual, participatory, and closely connected to situations encountered in everyday life.

The findings also indicated that ESD principles had not yet been systematically integrated into literacy activities and the use of digital learning media. This condition highlighted a need for learning activities that connect reading literacy with environmental, social, and sustainability-related contexts. The descriptive results for the three ESD indicators examined in this study are presented in Table 2.

Table 2. Results of the Education for Sustainable Development (ESD) Indicators

No.	ESD Indicator	Percentage	Category
1	Environmental awareness	70%	Moderate
2	Sustainable behavior	63%	Moderate
3	Social collaboration	72%	Moderate

As shown in Table 2, all three ESD indicators were categorized as moderate. Social collaboration recorded the highest percentage (72%), followed by environmental awareness (70%), while sustainable behavior showed the lowest achievement (63%). These results indicate that students had begun to demonstrate environmental awareness and social collaboration, but the translation of such awareness into consistent sustainable behavior remained comparatively limited. Together with the reading literacy findings, these results identified a need for learning experiences that integrate reading activities with contextual sustainability issues and encourage students not only to understand sustainability-related information but also to reflect on its relevance to their everyday choices and actions.

3. Development of the ESD-Based Digital Literacy Application

Based on the literacy and ESD-related needs identified in the preceding analysis, an *Education for Sustainable Development* (ESD)-based digital literacy application was developed as an interactive and contextual learning medium. The application was designed to support reading literacy while providing students with opportunities to engage with sustainability issues encountered in everyday life. Thus, its development was directly informed by the identified difficulties in reading comprehension, identifying main ideas, interpreting texts, connecting textual information with real-life contexts, and reflecting on reading, as well as by the need to strengthen students' sustainable behavior.

The application was designed for flexible access through computers and smartphones, allowing literacy activities to be conducted both at school and at home. Its main features include ESD-based digital reading materials, interactive quizzes, reading comprehension assessments, educational videos, points and rewards, and reflective activities connected to students' everyday experiences. The interface was designed to be simple, interactive, and accessible for elementary school students.

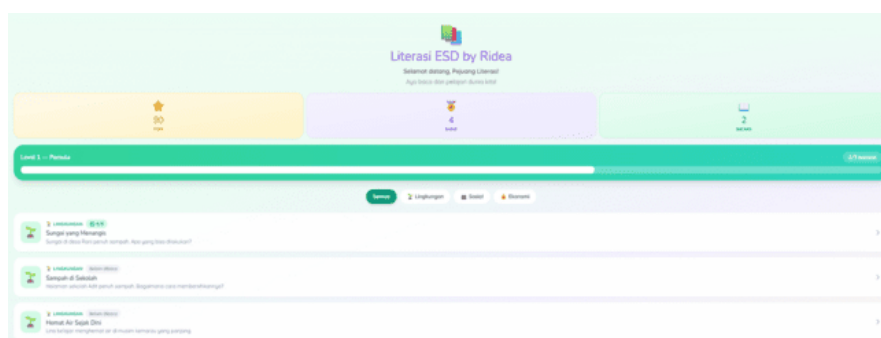


Figure 1. Main Interface of the ESD-Based Digital Literacy Application

As shown in Figure 1, the main interface provides access to ESD-based digital reading materials organized around environmental, social, and economic sustainability themes. The application also incorporates points, *badges*, and levels as gamification features intended to support student engagement. The digital reading materials present contextual stories related to everyday situations and sustainability issues using language appropriate for elementary school students.

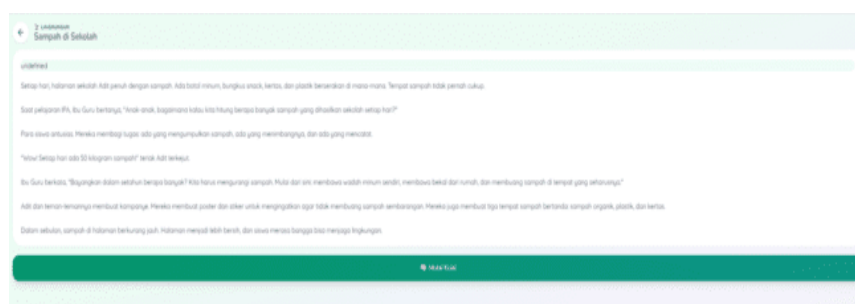


Figure 2. ESD-Based Digital Reading Materials

As illustrated in Figure 2, the digital reading feature includes contextual stories addressing environmental issues. These materials were designed to provide opportunities for students to practice reading comprehension while engaging with sustainability-related content. In addition to the reading materials, the application includes interactive multiple-choice quizzes with immediate feedback, enabling students to check their understanding of the texts they have read.

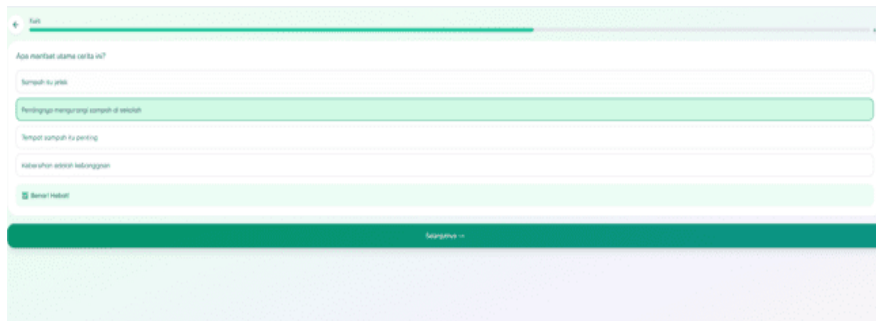


Figure 3. Interactive Digital Literacy Quiz

As shown in Figure 3, the interactive quizzes were designed to address reading literacy skills, particularly comprehension and the identification of important information, while providing an interactive learning activity within the ESD context. The application content integrates three sustainability dimensions: environmental, social, and economic. Environmental content includes waste management, energy conservation, and preservation of the school environment. The social dimension is represented through themes such as cooperation, tolerance, and care for others, whereas the economic dimension introduces responsible consumption, saving habits, and the wise use of resources.

In addition to reading and quiz activities, reflective activities were incorporated to encourage students to relate the information presented in the texts to their own experiences, choices, and actions. This design responds particularly to the relatively low achievement in connecting reading content with everyday life identified in the needs analysis. Overall, the resulting prototype integrates contextual reading materials, sustainability content, interactive activities, multimedia resources, gamification elements, and reflection within a single digital learning environment. At this stage, these features represent the design characteristics of the developed prototype rather than evidence of its effectiveness in improving reading literacy or ESD-related competencies; such effects require subsequent empirical testing.

B. Discussion

The findings revealed that fourth-grade students' reading literacy remained at low to moderate levels. Students achieved 58% in reading comprehension, 54% in identifying main ideas, 56% in interpreting texts, 52% in connecting reading content with everyday life, and 60% in reflecting on reading content. These results indicate that students' literacy challenges extend beyond literal comprehension to the ability to process, interpret, and apply textual information contextually. This finding is consistent with Hidayati et al. (2024), who reported that low literacy achievement among elementary school students is associated with difficulties in understanding information, limited reading habits, and insufficient instructional support for literacy development.

Connecting reading content with everyday life was the lowest-performing aspect, followed by identifying main ideas. This pattern suggests that reading instruction needs to extend beyond locating explicit information toward activities that require students to interpret, connect, and reflect on textual information. At the elementary level, meaningful reading experiences should enable students to relate texts to their prior knowledge and everyday experiences. Learning activities involving problem-solving and text interpretation may provide opportunities for students to engage more actively and meaningfully with reading materials (Hidayah et al., 2024). The relatively low performance in contextualizing textual information therefore represents an important instructional need that should be addressed in the design of literacy learning activities.

The findings also showed that existing school literacy initiatives, including reading activities before lessons and classroom reading corners, had not yet developed into sustained reading habits. Literacy activities remained predominantly situated within formal school routines and had not consistently extended into students' learning practices outside the classroom. This finding suggests that the availability of literacy facilities alone may be insufficient without activities that continuously engage students with reading. Natalia et al. (2024) similarly emphasized that literacy initiatives involving classroom reading corners need to be accompanied by engaging and sustained activities to strengthen students' reading habits.

Within this context, digital media may provide an alternative means of extending students' opportunities and experiences with reading. Digital technology allows reading materials and learning activities to be accessed more flexibly and enables information to be presented through combinations of text, visual content, and interactive activities. Nevertheless, digital media should be positioned as a means of supporting reading literacy rather than as the learning objective itself. Previous studies have indicated that appropriately designed digital media can support student engagement, access to learning resources, and more varied literacy experiences in elementary education when aligned with students' pedagogical needs (Hidayat & Khotimah, 2019; Pratiwi & Setyaningrum, 2022; Yulianti & Hartanto, 2021).

The analysis of Education for Sustainable Development indicators showed that environmental awareness reached 70%, sustainable behavior 63%, and social collaboration 72%, with all three indicators categorized as moderate. Sustainable behavior represented the lowest-performing indicator, suggesting a potential gap between students' awareness of sustainability-related values and their consistent enactment in everyday behavior. This finding reinforces the view that sustainability education should extend beyond transmitting environmental knowledge toward learning experiences that connect knowledge and values with decision-making and actions in authentic contexts (Sari & Mulyono, 2021). The relatively lower level of sustainable behavior therefore provided an additional rationale for incorporating situations requiring students to consider the consequences of everyday choices into the proposed learning application.

Integrating ESD with reading literacy is particularly relevant because texts can provide meaningful contexts for introducing environmental, social, and economic issues while simultaneously developing students' abilities to comprehend, interpret, and evaluate information. In the present study, sustainability was not treated merely as a thematic addition to reading materials. Instead, sustainability contexts were incorporated to encourage students to connect textual information with everyday experiences, consider the consequences of particular actions, and reflect on choices related to environmental, social, and economic sustainability. This approach is consistent with ESD principles that position education as a means of developing knowledge, awareness, responsibility, and capacities for informed action regarding sustainability challenges (UNESCO, 2017; Sari & Mulyono, 2021).

The literacy and ESD needs identified in the study were subsequently translated into the design of the digital application prototype. The application integrates digital reading materials addressing environmental, social, and economic themes with interactive quizzes, educational videos, comprehension assessments, reflective activities, points, and rewards. Contextual reading materials were incorporated specifically in response to students' relatively low ability to connect texts with everyday life, while quizzes and reflective activities were designed to provide opportunities for students to examine and reflect on their understanding. The combination of digital content and interactive learning activities may provide more varied literacy experiences that are relevant to contemporary learning environments (Pratiwi & Setyaningrum, 2022; Wijayanti et al., 2025).

The application was also designed to extend literacy activities beyond face-to-face classroom instruction. Access through computers and smartphones allows reading materials and learning activities to be used beyond formal classroom hours. Such flexibility may create opportunities for more independent literacy engagement; however, this potential depends on practical conditions such as access to devices and connectivity, teacher and parental support, and students' readiness to engage with digital learning. Digital learning in elementary education therefore requires more than access to technology; it requires the alignment of technological use with meaningful learning

activities and students' ability to engage responsibly with digital information (Redecker, 2017; Yulianti & Hartanto, 2021).

From an instructional development perspective, an important implication of these findings is that technology selection should follow the identification of learning needs rather than precede it. Students' difficulty in connecting reading content with everyday life provided the rationale for incorporating contextual texts and reflective activities, while the moderate achievement of ESD indicators informed the integration of sustainability-oriented content. Consequently, the features of the application were designed as responses to empirically identified learning needs rather than as technological additions without a clear pedagogical function. This needs-driven approach is consistent with the view that digital media are more educationally meaningful when their design is aligned with learning objectives, learner characteristics, and the competencies to be developed (Pratiwi & Setyaningrum, 2022; Wijayanti et al., 2025).

The contribution of this study lies in connecting reading literacy and Education for Sustainable Development within the design of an integrated digital learning environment. Rather than developing a digital medium that merely delivers reading materials, the proposed prototype combines text comprehension, interactive quizzes, reflection, and sustainability content encompassing environmental, social, and economic dimensions. More importantly, these components were derived from the needs identified in the empirical analysis. This integration broadens the intended role of literacy learning from understanding textual information toward using information to interpret issues related to everyday life and sustainability (Sari & Mulyono, 2021; Pratiwi & Setyaningrum, 2022).

However, the present findings should not be interpreted as evidence that the developed application improves students' reading literacy or ESD-related competencies. The study was limited to needs analysis and prototype development and did not examine changes in student outcomes following application use. Moreover, the needs analysis involved only 30 fourth-grade students selected through purposive sampling, which limits the extent to which the identified needs can be generalized to broader elementary school populations. Subsequent research should therefore include expert validation, readability and usability evaluation, limited-scale implementation, and controlled empirical testing of students' reading literacy and ESD-related outcomes before and after application use. A staged approach to the development and evaluation of educational technology is necessary to establish not only the technical and practical quality of digital media but also their empirically demonstrated contribution to learning (Redecker, 2017; Wijayanti et al., 2025).

IV. CONCLUSION

The findings indicate that fourth-grade students' reading literacy remained at low to moderate levels, with the lowest achievement observed in connecting reading content with everyday life (52%) and identifying main ideas (54%). The ESD-related indicators were at moderate levels, including environmental awareness (70%), sustainable behavior (63%), and social collaboration (72%). Based on these identified needs, the study developed an ESD-based digital application prototype integrating contextual reading materials, interactive quizzes, educational videos, reflective activities, and sustainability content encompassing environmental, social, and economic dimensions. The prototype was designed to address the identified literacy and ESD-related needs by connecting reading activities with meaningful sustainability contexts. However, as the present study focused on needs analysis and prototype development, no conclusions can yet be drawn regarding the application's effectiveness in improving reading literacy or ESD-related competencies. Further research should therefore include expert validation, readability and usability testing, limited-scale implementation, and controlled empirical evaluation before claims regarding the application's effectiveness can be established.

CONFLICT OF INTEREST

The authors report no competing interests related to this research. No personal, professional, or financial relationships were identified that could reasonably be perceived as influencing the design, interpretation, or reporting of the study.

AUTHOR CONTRIBUTIONS

Rifqi Komara: Conceptualization, Investigation, Data Curation, and Writing – Original Draft. **Dede Wahyudi:** Methodology, Investigation, and Writing – Review & Editing. **Agustina:** Validation, Data Analysis, and Writing – Review & Editing. **Eri Sarimanah:** Conceptualization, Supervision, and Critical Review. **Dadang Jaenudin:** Methodological Review, Validation, and Supervision. **Mira Mirnawati:** Validation, Critical Review, and Manuscript Refinement. All authors contributed to the development of the study, reviewed the manuscript for important intellectual content, and approved the final version for publication.

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DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

Generative AI and AI-assisted tools were utilized in a limited capacity during manuscript preparation, particularly for linguistic refinement, proofreading, and enhancing the clarity of academic expression. The research process—including the formulation of the study, data collection, analysis, interpretation of findings, and development of conclusions—remained under the responsibility and intellectual oversight of the authors. AI-assisted tools were not used to create or alter research data or to generate unsupported research findings or references. All AI-assisted revisions were subsequently examined and, where necessary, modified by the authors. The authors assume full responsibility for the accuracy, originality, and integrity of the published work.

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