

Development of Science E-Modules Based on Education for Sustainable Development (ESD) for Grade III Elementary School/Islamic Elementary School Students

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Abstract. Availability of integrated science teaching materials for understanding concepts and issues of sustainability remains a need in basic school research. This study develops e-IPAS modules based on Education for Sustainable Development (ESD) on the material cycle and creature life, as well as analyzes feasibility and attractiveness. Research method: Research and Development (R&D) with the ADDIE model, which includes analysis, design, development, implementation, and evaluation. Validation involved six validators, while the trial was conducted on 15 students of class III E, 32 students of class III B, and two teachers in one madrasah. Data were collected through expert validation sheets and questionnaires of educator and student responses. The results showed an average expert validation of 89.00% with the very feasible category, covering 90.62% of material, 88.12% of media, and 88.27% of language. The educator response reached 86.10%, while the product's attractiveness was 91.73% in small groups and 92.62% in field trials. The product is suitable for use as a companion teaching material for sustainability-based science and education.

Keywords: E-module; Life Cycle of Living Things; Elementary School; Digital Teaching Materials; Lower Grades.

1. Introduction

Basic education plays a strategic role in forming knowledge, attitudes, and habits that participants use to respond to problems in the environment and social life (Lamanauskas, 2023; Gagaramusu et al., 2025; Nofri et al., 2026). In learning Knowledge Natural and Social Sciences (IPAS), participants educate not only directed understand phenomenon natural and social, but also the interconnectedness between action humans, utilization source power and sustainability life. This orientation aligns with the Independent Curriculum (Sukma et al., 2020; Wulandari et al., 2023; Gelmez & Reiss, 2024; Muthi & Sujarwo, 2025), which emphasizes contextual learning, competency strengthening, and student character development (Fitriyah & Wardani, 2022; Fauzan et al., 2023; Safitri & Rahim, 2024). Its implementation is increasingly relevant to digital developments in Indonesia, as demonstrated by the implementation of the Independent Curriculum in more than 300,000 educational institutions, or approximately 80% of formal educational institutions, by 2024, and the increase in internet access from 69.21% in 2023 to 72.78% in 2024 (Statistics, 2025). This situation opens up opportunities for the development of digital teaching materials that connect science and science learning with sustainability-oriented education.

One approach relevant to this orientation is Education for Sustainable Development (ESD), an educational approach that integrates environmental, social, and economic dimensions into the learning process (Gunansyah et al., 2021; Gorski et al., 2023; Zaman et al., 2025). ESD not only builds

understanding of sustainability issues but also develops the ability to make decisions and act responsibly (Lamanauskas & Malinauskienė, 2024). Globally, 107 countries have developed or implemented initiatives for Education for Sustainable Development by 2030, and 2,800 stakeholders interested in education and the environment from 161 countries have agreed to the Berlin Declaration on ESD (UNESCO, 2024). However, mainstreaming ESD in curriculum and learning is not optimal. UNESCO (2024) reported that 47% of national curriculum frameworks out of 100 countries have listed climate change, while only 40% of teachers feel they can teach the dimensions of cognitive change related to climate, and 20% are capable of explaining concrete actions to overcome it. This fact indicates a gap between the global commitment (Beach, 2023; Alam, 2026; Assaraf et al., 2025) to ESD and the ability of educational units to translate it into operational learning.

This gap was also found in the context of science learning in elementary schools. Based on pre-research at MIN 6 Bandar Lampung on January 12–13, 2026, through observations and interviews with third-grade teachers, learning still relies on teacher-made printed modules and has not yet used e-modules that integrate environmental, social, and economic dimensions. The material has not been systematically linked to habits of maintaining cleanliness and environmental sustainability, collaborating in social life, and utilizing resources wisely. Students also have difficulty understanding the material because the presentation is not visual, interactive, and contextual to everyday experiences. These conditions show that the availability of technology and digitalization policies do not automatically produce contextual and sustainability-oriented science learning if not supported by teaching materials that are appropriate to the cognitive characteristics of lower-grade students.

Several studies have demonstrated the potential of digital teaching materials and ESD in improving the quality of learning. Fitria & Hamdu (2021) developed an ESD-based mobile learning application suitable for use in elementary schools. Maharcika et al. (2021) showed that flipbook-based e-modules are able to present material systematically, attractively, and flexibly, while finding that Fatmianeri et al. (2021) differentiated instruction-based electronic modules can accommodate the different needs of learners. El-Hamamsy et al. (2024) emphasized that the sustainability of technology use is not only determined by the device, but also by the quality of learning design, teacher support, and its integration with classroom practice. In the context of ESD, Timm & Barth (2021) emphasized the role of teachers in translating sustainability into concrete learning experiences, while Sinakou et al. (2022) demonstrated the importance of inquiry, decision-making, and action on real-world problems. In developing teaching materials, Fauzi & Nugraha, (2022) strengthened critical thinking through the ADDIE model; Novianti et al. (2023) changed the environment, whereas Najwa & Suhartini (2023) focused on Science Education for Sustainable Development. Silvia & Widyaningrum (2023). The next research includes e-modules on global warming. The next research includes e-modules on global warming (Berlianti W.M. et al., 2024), bioplastics with 86.5% student satisfaction (Sari et al., 2024), integration of ESD with local wisdom on climate change material (Pangsuma et al., 2024), and translation of ESD principles into pedagogical practices of the Independent Curriculum (Pratiwi et al., 2025). In general, the research shows that ESD-based e-modules have the potential to support flexible, multimodal, contextual, and competency-oriented learning.

However, a synthesis of previous research indicates that the development of ESD-based e-modules is still more focused on upper-grade or secondary school students, hydroponics, environmental change, global warming, and bioplastics, and is oriented towards product feasibility or critical thinking skills. The ESD dimension in a number of products also tends to emphasize environmental aspects. In contrast, balanced integration between environmental, social, and

economic dimensions, their application to lower-grade students, and flexibility in online and offline use have not received consistent attention. Thus, the research gap in this study lies in the limited number of science e-modules that are simultaneously adapted to the cognitive characteristics of third-grade elementary school students, discuss the life cycle of living things, and operationalize the three dimensions of ESD through activities close to students' lives. This study fills this gap by developing an e-module using the ADDIE model with a simple, visual, interactive, contextual presentation, and adaptability to connectivity conditions. Its novelty lies in the configuration of the integration of the three dimensions of ESD, lower-grade student characteristics, life cycle material, contextual activities, visual and interactive elements, learning evaluation, and flexibility in online and offline use, not in claiming to be the first research.

This development is important because lower-grade students need teaching materials that are not only practical, interesting, and easily accessible, but also able to instill the value of sustainability through concrete learning experiences that are close to everyday life. The integration of ESD in the material of the life cycle of living things is expected to help students understand the concept while building awareness, knowledge, and attitudes in maintaining the sustainability of life and the environment. This need is reinforced by the results of pre-research at MIN 6 Bandar Lampung, which show the need for interesting, contextual, and usable science and natural science teaching materials at school and at home. Therefore, this study aims to develop an ESD-based science and natural science e-module on the life cycle of living things material for third-grade elementary school students using the ADDIE model, analyze its feasibility based on expert assessments of the material, media, and language, and analyze the responses of educators and students to the developed product. Theoretically, this study is expected to expand the study of the operationalization of environmental, social, and economic dimensions in science and natural science teaching materials for lower-grade students. In practice, this research is expected to produce digital teaching materials that are appropriate to the characteristics of students and learning needs at MIN 6 Bandar Lampung and become a reference for teachers in integrating sustainability values into science learning.

2. Method

This study uses the Research and Development (R&D) method to produce and evaluate the feasibility of an Education for Sustainable Development (ESD)-based science e-module on the life cycle of living things for third-grade elementary school students. R&D was chosen because it allows product development through a systematic process of needs analysis, design, development, validation, implementation, and evaluation (Branch, 2009; Waruwu, 2024). The study was conducted at MIN 6 Bandar Lampung in the even semester of the 2025/2026 academic year. The study was limited to product development, feasibility assessment, and attractiveness of the e-module, without testing its effectiveness on learning outcomes or changes in sustainable behavior. E-module development used the ADDIE model, consisting of five stages, namely analysis, design, development, implementation, and evaluation. The product was developed in the form of a web-based science and natural sciences e-module containing materials, illustrations, learning videos, ESD-based contextual activities, and learning evaluations. The materials and activities integrate environmental, social, and economic dimensions and are tailored to the learning outcomes and characteristics of third-grade elementary school students – the procedure development is presented in Figure 1.

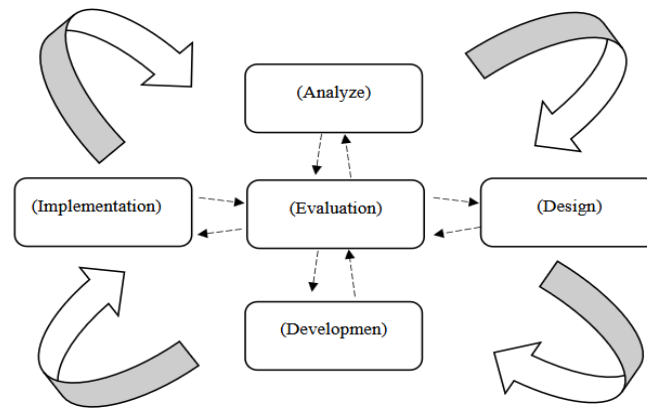


Figure 1. E-module development procedure using the ADDIE model

The analysis phase includes an analysis of needs, curriculum, and student characteristics. The needs analysis was conducted through non-participatory observation and interviews with two third-grade teachers to identify learning conditions, the use of teaching materials, and the need for ESD integration. The curriculum analysis was conducted by examining learning outcomes and materials on the life cycle of living things, as well as mapping environmental, social, and economic dimensions. The analysis of student characteristics included learning needs, language and visual comprehension skills, experience using digital media, and the context of everyday life. The analysis results were used as a basis for determining the content, language, activities, appearance, and presentation format of the e-module.

The design stage is carried out through the formulation of learning objectives, mapping of ESD materials and dimensions, compiling the e-module structure, designing activities and evaluations, and determining visual elements, navigation, and learning videos. The environmental dimension is operationalized through concern for living things and their habitats, the social dimension through cooperation and responsibility, while the economic dimension is operationalized through the wise use of resources. The e-module structure includes a cover, instructions for use, learning objectives, materials, visual and video media, ESD-based activities, evaluations, and a bibliography. At this stage, expert validation instruments and questionnaires for educator and student responses are also prepared.

The development stage involved realizing the design into an e-module prototype and validating it with six validators: two material experts, two media experts, and two language experts. The validators provided scores, comments, and suggestions that were used as a basis for determining the feasibility and revising the product before the trial. Validator composition and aspects evaluation are presented in Table 1.

Table 1. Validators and product assessment aspects

Validator	Amount	Aspect Evaluation	Amount Item
Subject matter expert	2 persons	Quality of content, presentation, and validation decisions	11
Media expert	2 persons	Display, presentation, and validation decisions	10
Linguist	2 persons	Cover, language in the foreword and contents, and validation decisions	7
Amount	6 people	—	28

The implementation stage was carried out after the product was revised based on the results of expert validation. Small group trials involved 15 students in grade III E, while field trials involved

32 students in grade III B of MIN 6 Bandar Lampung. Two third-grade homeroom teachers were also involved to provide feedback on product use. Students assessed aspects of the appearance, material, language, presentation, ease of use, and benefits of the e-module. In contrast, educators assessed aspects of the appearance, presentation, material/content, language, and product use. Data sources, instruments, and data collection objectives are presented in Table 2.

Table 2. Data sources, instruments, and data collection objectives

Stage	Data source	Amount	Instrument	Purpose of Data Collection
Analysis need	Grade III teacher	2 persons	Guidelines for interviews and observations	Identifying learning conditions and teaching material needs
Validation material	Science subject expert	2 persons	Validation sheet material	Assess the appropriateness of the content and presentation of the material.
Media validation	Learning media expert	2 persons	Media validation sheet	Assess the appropriateness of media display and presentation
Validation Language	Indonesian Language Expert	2 persons	Validation sheet Language	Assessing the appropriateness and readability of language
Response educator	Homeroom teacher for class III	2 persons	Questionnaire response educator	Assess the appearance, materials, language, presentation, and use of the product.
Group test small	Student class III E	15 people	Questionnaire response participant education	Identifying initial usage attractions and constraints
Field test	Student class III B	32 people	Questionnaire response participant education	Confirming product appeal to a wider audience

The evaluation phase is conducted formatively at each stage of ADDIE. The evaluation includes conformance to product specifications, the accuracy of the ESD design and activities, expert validation results, and educator and student responses. The final product is obtained after relevant quantitative and qualitative input is used as a basis for e-module refinement.

Data were collected through interviews, observations, and questionnaires. Interviews and observations were used to obtain information regarding science learning, student characteristics, use of teaching materials, and e-module development needs. The questionnaire was used to obtain expert validation data and responses from educators and students (Kurniawan, 2022; Siregar, 2022). The questionnaire used a five-level Likert scale: very good (5), good (4), sufficient (3), poor (2), and very poor (1).

The data consisted of qualitative and quantitative data. Qualitative data, in the form of comments and suggestions from validators and users, were analyzed descriptively and used as the basis for product revisions. Quantitative data, in the form of validation scores and user responses, were analyzed using descriptive statistics in percentage form using the following formula.

$$P = \frac{\sum X}{X_{\text{maks}}} \times 100\%$$

The maximum score is obtained by multiplying the highest score on the assessment scale by the number of items and the number of assessors. The expert validation percentage is used to determine the level of feasibility, while the percentage of educator and student responses is used to

determine the level of product attractiveness (Aulia et al., 2022). Criteria: the interpretation is presented in Table 3.

Table 3. Criteria for interpreting product feasibility and attractiveness

Percentage	Criteria Eligibility	Criteria Attraction
$80 < P \leq 100$	Very worthy	Very interesting
$60 < P \leq 80$	Worthy	Interesting
$40 < P \leq 60$	Enough worthy	Enough interesting
$20 < P \leq 40$	Not worthy	Less attractive
$0 < P \leq 20$	Not feasible	Not attractive

An e-module is deemed feasible if it achieves a validation percentage ($P > 60$) and receives a positive response if the user assessment reaches the minimum attractive category ($P > 60$). Quantitative scores are used to determine the feasibility and attractiveness of the product, while qualitative feedback is used as a basis for product improvement.

3. Result

The study produced IPAS-based e-modules for Education for Sustainable Development (ESD) on the material cycle life creature life for student grade III SD/MI through the ADDIE stages. The analysis shows that science learning at MIN 6 Bandar Lampung uses the Independent Curriculum. However, it is still dominated by printed teaching materials and has not systematically integrated environmental, social, and economic dimensions. Students need teaching materials with simple language, attractive visual displays, and support from images, videos, and contextual activities. These findings form the basis for the development of a web-based e-module that integrates the three ESD dimensions, as summarized in Table 4.

Table 4. Results of the analysis of needs and characteristics of e-module development

Aspect	Findings	Implications to Product
Curriculum	Learning uses the Independent Curriculum and refers to the learning outcomes and learning objectives flow for Grade III Science.	The e-module materials and activities are adapted to the learning outcomes of science and the learning objectives of Grade III.
Need Learning	Teaching materials are still dominated by books and printed teaching materials, while the use of interactive digital teaching materials is still limited.	A web-based e-module was developed as a companion teaching material that can support digital and interactive learning.
ESD Integration	Teaching materials have not yet integrated environmental, social, and economic dimensions systematically.	The dimensions of Education for Sustainable Development (ESD) are integrated into materials, examples, and learning activities.
Characteristics Learners	Learners need simple language, pictures, videos, and activities that are close to everyday life.	The e-module is designed to be visual, interactive, contextual, and appropriate to the characteristics of Grade III students.

Based on the analysis, the e-module was designed using Canva in vertical A4 format and presented in a web-based format. The product includes a cover, user manual, learning objectives, life cycle materials, images and videos, ESD-based activities, evaluations, and a bibliography. The prototype was then validated by two material experts, two media experts, and two linguists. The

material validation resulted in an overall percentage of 90.62%, categorized as very feasible, as shown in Table 5.

Table 5. Validation results: expert material

Aspect Evaluation	Validator 1	Validator 2	Average	Criteria
Content Quality	85.00%	87.50%	86.25%	Very Worthy
Presentation	90.00%	100.00%	95.00%	Very Worthy
Overall	—	—	90.62%	Very Worthy

Validation media experts obtained an overall mark of 88.12%, while validation expert Language reached 88.27%. All aspects are in the very suitable category (Table 6).

Table 6. Results of validation by media and language experts

Field Validation	Aspect Evaluation	Validator 1	Validator 2	Average Aspect	Overall Average	Criteria
Media	Appearance	87.50%	85.00%	86.25%	88.12%	Very Worthy
Media	Presentation	80.00%	100.00%	90.00%	—	Very Worthy
Language	Cover	86.60%	93.30%	89.95%	88.27%	Very Worthy
Language	Foreword and Module Contents	86.60%	86.60%	86.60%	—	Very Worthy

The validation results recapitulated and showed the highest score for the material aspect at 90.62%, followed by language at 88.27% and media at 88.12%. The overall average of 89.00% indicates that the e-module is in the very feasible category and can proceed to the implementation stage after revision (Table 7).

Table 7. Recapitulation results validation product

Component Validation	Number of Validators	Percentage	Criteria	Decision
Material	2	90.62%	Very Worthy	Can be tested after revision
Media	2	88.12%	Very Worthy	Can be tested after revision
Language	2	88.27%	Very Worthy	Can be tested after revision
Average	6	89.00%	Very Worthy	Can proceed to the implementation stage

Product revisions were made based on validator input on material, media, and language aspects. Improvements included strengthening the context of everyday life, aligning questions with learning objectives, consistent fonts, refining the sequence of activities, adjusting images and colors, and simplifying the language to suit the characteristics of third-grade students. Revision results are presented in Table 8.

Table 8. Product revisions based on validator input

Field	Condition Before Revision	Revision Results
Field	Condition Before Revision	Revision Results
Material	The material has not been fully linked to students' daily activities.	The material is adapted to students' daily experiences and activities to make it more contextual.

Material	The questions are not fully aligned with the learning material.	Questions are adapted to learning objectives and the material presented.
Media	The use of fonts is not consistent.	The font is improved and used consistently throughout the e-module.
Media	Activity learning needs adjustments.	The appearance and sequence of learning activities have been improved to make them more systematic and easier for students to follow.
Media	The image and colors are not completely harmonious.	Images and colors are adjusted to the content of the material and student characteristics.
Language	The language is not fully suited to the characteristics of third-grade students.	The language is simplified to make it easier to understand and appropriate to the developmental level of students.

After revision, the product was implemented through small group trials and field trials. The small group trial of 15 students in Grade III E obtained a score of 688 out of a maximum score of 750, or 91.73%, categorized as very engaging. The field trial of 32 students in Grade III B obtained a score of 1,482 out of a maximum score of 1,600, or 92.62%, also categorized as very engaging. These results demonstrate consistent positive acceptance of the e-module across a broader group of students (Table 9).

Table 9. Trial results: participant education

Trial Phase	Subject	Total Score	Maximum Score	Percentage	Criteria
Small Group	15 students, Class III E	688	750	91.73%	Very interesting
Field Test	32 students, Class III B	1,482	1,600	92.62%	Very interesting

The assessment by two educators yielded an overall score of 86.10%, categorized as very adequate. The appearance aspect received the highest score of 95.50%, followed by use (90.00%), material/content (85.00%), and presentation and language, each received 80.00% (Table 10).

Table 10. Assessment results educator

Aspect	Educator 1	Educator 2	Average	Criteria
Appearance	91.00%	100.00%	95.50%	Very Worthy
Presentation	80.00%	80.00%	80.00%	Worthy
Material/Content	70.00%	100.00%	85.00%	Very Worthy
Language	70.00%	90.00%	80.00%	Worthy
Use	100.00%	80.00%	90.00%	Very Worthy
Overall	—	—	86.10%	Very Worthy

A comparison of all results shows that expert validation and user responses are in the feasible to very feasible/interesting categories. The feasibility percentage for material experts reached 90.62%, media experts 88.12%, and language experts 88.27%, while student responses reached 91.73% in the small group test and 92.62% in the field test. Educator responses reached 86.10%.

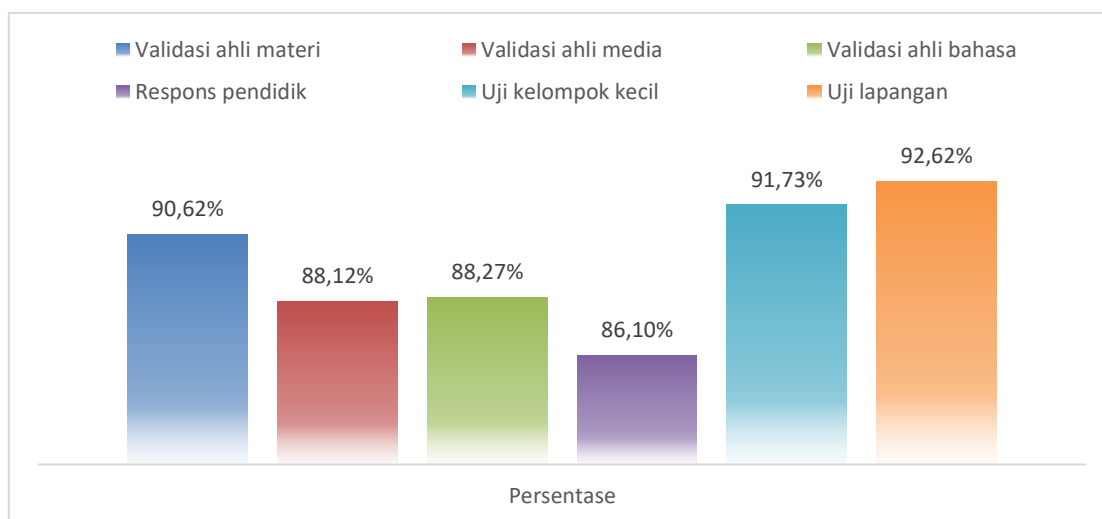


Figure 2. Comparison of Validation Results and User Responses

Evaluation at all stages resulted in product improvements in terms of material, alignment of evaluation with learning objectives, appearance, language readability, images, colors, and user instructions. The final product is an ESD-based science and education e-module that integrates environmental, social, and economic dimensions through text, images, videos, learning activities, and evaluations. Overall, the validation and trial results indicate that the e-module meets the eligibility criteria based on expert and educator assessments and is categorized as very interesting based on student responses.

4. Discussion

The Education for Sustainable Development (ESD) based science and education e-module meets the criteria of being highly feasible according to experts and educators and is highly engaging according to students. The average expert validation score of 89.00% indicates that the material, media, and language aspects have a relatively balanced level of feasibility. These results demonstrate that the stages of analysis, design, development, implementation, and evaluation can be used to develop digital teaching materials that are appropriate to learning needs. However, these findings only demonstrate the feasibility and attractiveness of the product, not its effectiveness on learning outcomes, ESD competencies, or students' sustainable behavior.

The development of e-modules stems from the need for third-grade students to have more visual, interactive teaching materials, using simple language, and relating to everyday experiences. Previously used printed teaching materials were not fully able to meet these needs. Therefore, e-modules were developed by combining text, images, videos, activities, and evaluations. Hidayat et al. (2024) demonstrated that digital media in science learning can expand the presentation of material and support student engagement, while Maharcika et al. (2021) emphasized that e-modules can present material in a structured, engaging, and flexible manner. This study expands these functions by integrating a sustainability perspective into science learning.

ESD integration encompasses environmental, social, and economic dimensions. The environmental dimension is realized through activities such as maintaining cleanliness, caring for living things, and understanding the relationship between them and their habitats; the social dimension through cooperation, mutual assistance, caring, and responsibility; and the economic dimension through the efficient and wise use of resources. These three dimensions are connected to students' daily experiences to facilitate their understanding of the concept of sustainability. This finding aligns with Vioreza et al. (2023), who emphasized that ESD in the Independent Curriculum

can connect learning materials to life's issues, and Siregar et al. (2025), who positioned ESD as a framework for integrating environmental issues and sustainable living.

The feasibility of this integration is reflected in the validation by material experts of 90.62%. This result indicates that the material on the life cycle of living things and the ESD content are in line with the learning characteristics of third-grade students. This finding supports Najwa (2023), who showed that integrated ESD e-modules can produce appropriate and contextual teaching materials, as well as Fauzi and Nugraha (2022), who received a positive response to the ESD e-module on the topic of hydroponics. The difference is that this study uses the material on the life cycle of living things as the ESD context. This shows that the concept of sustainability can be introduced through basic science material that is close to students' lives, not only through complex environmental issues.

Media validation of 88.12% and language validation of 88.27% also indicated that the visual presentation and readability of the e-module met the criteria of being very appropriate. For third-grade students, the visual display, images, navigation, and audiovisual media helped to concretize information, while simple language facilitated student participation in learning activities. These findings align with Fitria and Hamdu (2021), who emphasized the integration of content, display, and user needs in the development of ESD-based mobile learning, and WM et al. (2024), who demonstrated the importance of appropriate material and presentation in determining the appropriateness of the e-module. Nevertheless, validator input was still used to improve the relevance of the material to everyday life, the appropriateness of the questions, and the consistency of fonts, images, colors, and language use. Educator responses of 86.10% reinforced the product's appropriateness, although aspects of presentation and language still require attention for more efficient use in real-life learning.

Product acceptability was also evident in the student responses, which reached 91.73% in the small group test and 92.62% in the field test. The consistency of these results indicates that the e-module's appearance, materials, language, activities, and ease of use were well-received by students. This supports Novianti et al. (2023), who reported a very good response to ESD-based e-modules, and Damayanti and Widyaningrum (2023), which shows the potential of online module-based Science Education for Sustainable Development. However, the difference is 0.89 percentage points between the two tests and only shows a change in attractiveness and cannot be interpreted as an improvement in results because this study did not use pre- and post-learning measurements or group comparisons.

Compared to previous research, this study's contribution lies in the integration of science, digital technology, and three dimensions of ESD through the life cycle of living things material for third-grade elementary school students. Previous research has often used the context of hydroponics, environmental change, global warming, and bioplastics, while this study uses basic concepts closer to the experiences of lower-grade students. Thus, the study's contribution lies in how environmental, social, and economic dimensions are integrated into a single, contextual digital teaching material, not in claiming to be the first such study.

However, the research results are limited by the implementation in one madrasah with six validators, 15 students in the small group test, 32 students in the field test, and two educators. These conditions limit the generalizability of the results. The use of e-modules is also influenced by the availability of digital devices, electricity, students' ability to use media, and the need for teacher or parental support. Furthermore, this study has not measured the effectiveness on learning outcomes, conceptual understanding, ESD competencies, learning independence, or sustainability behavior. Therefore, further research is needed using an experimental design with a broader subject scope. Academically, the research results indicate that ESD can be integrated into science learning through

digital teaching materials that are close to students' experiences. Practically, e-modules can be used as complementary teaching materials to enrich sustainability-based learning.

5. Conclusion

An Education for Sustainable Development (ESD) based science and science e-module on the life cycle of living things for third-grade elementary school students was developed through the ADDIE model. The results showed that the developed product met the criteria of being very feasible based on expert assessment, with an average of 89.00%. Specifically, material expert validation obtained 90.62%, media validation 88.12%, and language validation 88.27%. The educator response of 86.10% also placed the product in the very feasible category. In contrast, student responses showed a very high level of interest, namely 91.73% in the small group test and 92.62% in the field test. The difference of 0.89 percentage points between the two tests indicates that positive student responses remained consistent when the use of the product was expanded to larger groups.

Substantively, the development's contribution lies in the integration of science and natural sciences learning, digital technology, and three dimensions of ESD (environmental, social, and economic), within the context of life cycle material related to students' lives. This product can be used as a complementary teaching material to enrich science and natural sciences learning based on a sustainability context. However, the research results are still limited to the context of one madrasah with six validators, 15 students in small group testing, 32 students in field testing, and two teachers. This study also has not tested the effectiveness of conceptual understanding, ESD competencies, learning independence, or sustainability behavior. Therefore, further research needs to test the pedagogical effectiveness of the e-module through experimental designs or advanced designs with a wider range of subjects and contexts.

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