

DEVELOPMENT OF DIGITAL LITERACY AND ENVIRONMENTAL LITERACY INSTRUMENTS IN ECOLOGY AND BIODIVERSITY MATERIALS

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Abstract

This study aims to develop the feasibility of digital literacy and environmental literacy assessment instruments for junior high school students on ecology and biodiversity material. The research method used is development research with stages of instrument grid compilation, expert validation, and empirical testing. The results of content validation showed an 86.25% feasibility percentage with a highly suitable category. Empirical testing included validity, reliability, and difficulty index tests on 14 essay questions. The validity test results showed 9 valid and 5 invalid questions, while the reliability test yielded a Cronbach's Alpha coefficient of 0.6537, indicating that the instrument's consistency was in the adequate category. Based on these results, it can be concluded that the assessment instrument developed is suitable for measuring students' digital literacy and environmental literacy at secondary school level and is relevant to the demands of 21st-century learning. This instrument is expected to support teachers in the evaluation of continuous science learning and serve as the basis for the systematic and continuous development of contextual literacy assessment in Indonesian junior high schools.

Keywords: Digital Literacy, Environmental Literacy, Assessment.

1. Introduction

The issue of student literacy in Indonesia in the digital age, characterised by an explosion of information through online platforms, has become a crucial issue, with students finding it difficult to understand, evaluate, and use information critically. The results of the 2022 *Programme for International Student Assessment* (PISA) indicate that Indonesian students' reading literacy score is only 359, far below the OECD average of 476, reflecting junior high school students' inability to filter hoaxes and manipulative content on social media. This phenomenon is exacerbated by massive internet access but minimal digital competence, thereby reducing the capacity for critical thinking about digital information. At the junior high school level, this challenge is even more pressing given that students are in a transitional phase towards digital autonomy, while the national curriculum has not yet comprehensively integrated digital literacy training. The impact of this condition is that students are vulnerable to environmental disinformation, such as distorted narratives about climate change on social media, so junior high school education needs to adopt holistic learning strategies to anticipate contemporary information dynamics (Ozcan, et al., 2025).

Digital literacy is defined as the ability to access, evaluate, and use digital information ethically, while environmental literacy, which includes an understanding of ecological systems and sustainability principles, is a fundamental competency that needs to be developed in junior high school students as a generation growing up in a technology-based environment. Yanti's (2025) research findings show that students' digital literacy achievements in the critical thinking dimension are relatively high, at 84.09%, but there is still a gap in the functional and creativity dimensions, which are at 67.80% and 65.90% respectively. This gap indicates that students' ability to implement digital information contextually has not developed optimally, especially in responding to environmental issues. The integration of digital literacy and environmental literacy is a necessity, considering that the intensity of digital device use by junior high school students in the learning

process has not been balanced with the ability to relate digital information to local environmental issues, such as deforestation in Indonesia. The urgency of developing these two types of literacy is in line with the direction of the Merdeka Curriculum, which emphasises the mastery of 21st-century skills, where environmental literacy contributes to raising awareness of the achievement of *Sustainable Development Goals* (SDGs) 13 and 15. Without integrated literacy development, the learning process has the potential to produce students who are receptive to information rather than active participants in problem solving. Therefore, digital literacy and environmental literacy have a strategic role in supporting meaningful and contextual understanding of science subject matter.

Ecology and biodiversity material in the junior high school science curriculum has strategic potential as a basis for developing test instruments that can measure and encourage students' digital literacy and environmental literacy. Through the presentation of data-based stimuli, texts, or digital media that represent environmental issues, test instruments can be designed to assess students' ability to access, evaluate, and interpret information critically. Uzman's (2024) research shows that the use of contextually-based environmental issue instruments contributes to improving students' critical thinking skills in selecting digital information. At the junior high school level, the development of such instruments is relevant because it is in line with the characteristics of students who are becoming accustomed to using online sources in learning. However, the limitations of structured and integrated instruments with digital literacy and environmental literacy mean that the potential of ecological material has not been optimally utilised, so it is necessary to develop instruments specifically designed to support the achievement of these competencies.

The ecological and biodiversity learning instruments used in junior high schools in Indonesia are still dominated by conventional textbooks and simple student worksheets, which do not integrate digital literacy and environmental literacy in a measurable way. The results of the evaluation of the implementation of the 2013 Curriculum show that around 70% of science assessment instruments are still oriented towards *rote learning* and do not yet accommodate digital data analysis-based assessments, such as the interpretation of biodiversity change visualisations using geospatial technology. These limitations are reflected in research (Syaifulloh, 2025) which shows low student ability in digital collaboration on ecology learning projects, one of which is influenced by learning instruments that are not yet adaptive to the use of technology. Pedagogically, junior high school teachers tend to rely on static learning media and have not optimally utilised digital platforms, such as online learning management systems, to support simulations or explorations (Kustini, 2025). This condition has an impact on the suboptimal measurement of students' literacy development in a systematic manner, thereby hampering the achievement of 21st-century competencies and emphasising the urgency of developing learning instruments that are more comprehensive and responsive to the demands of the digital era.

Based on the limitations of learning instruments described above, the development of ecological and biodiversity material instruments integrated with digital literacy and environmental literacy is an urgent need at the junior high school level. The learning instruments developed are directed at the use of interactive digital activities, such as the presentation of questions based on environmental data from official sources, so that they are able to measure students' ability to analyse, evaluate, and use information critically. Afifah's (2025) research findings show that the use of digital media and instruments in science learning has a significant effect on improving students' science literacy, in line with the implementation of the Merdeka Curriculum. The development of instruments that take into account the characteristics and environment of junior high school students aims to ensure the relevance and meaningfulness of assessments through the application of authentic assessments, including the ability to present environmental information visually. This need is increasingly relevant considering that the mastery of digital literacy aspects, especially information security in ecological issues, is still not optimal. Therefore, an instrument that is systematically designed, integrated, and adaptive to technological developments is needed.

2. Research Method

2.1. Object, Time, and Place

The object of this study was Grade VIII A students at MTsN 2 Karanganyar who were involved in testing descriptive questions based on digital literacy and environmental literacy on ecology and biodiversity material. The study was conducted on 10 December 2025. The location of the study was at MTsN 2 Karanganyar, an educational unit that implements science learning in accordance with the applicable

curriculum. The scope of the research focused on the development and application of essay questions designed to measure students' ability to access, analyse, evaluate, and communicate digital information related to environmental issues. This study was limited to testing the quality of the questions and did not include an evaluation of the overall effectiveness of the learning model or method.

2.2. Data Collection Techniques

The data collection technique in this study used essay questions developed based on indicators of digital literacy and environmental literacy in ecology and biodiversity material. The question sheets were used as the main instrument to obtain data on students' ability to access, analyse, evaluate, and communicate digital information related to environmental issues. Data was collected through the implementation of instrument trials on Grade VIII A students in accordance with the designed procedures. Before use, the question sheets were compiled based on a literature review and validated theoretically to ensure the suitability of the questions with the indicators being measured. This technique was chosen because it was able to produce relevant and in-depth data related to the measurability of students' digital literacy and environmental literacy in accordance with the research objectives. The grid for the digital literacy description question sheet is presented in Table 1, and the grid for the environmental literacy description question sheet is presented in Table 2.

Table 1. Digital Literacy Grid

Operational Definition	Aspect	Indicators	Questions					Number of Questions
			C2	C3	C4	C5	C6	
The ability to understand and use information from various digital formats, with an emphasis on critical thinking and critical evaluation of information found through digital media (Gilster, 1997)	a) The ability to understand <i>information retrieval</i>	- Displaying effective keywords - Identifying credible sources - Verifying credible digital sources related to the material	1		3			2
	b) Ability to use information in hypertext navigation	- Searching for relevant links that support understanding of the topic - Identifying the structure of information from several interrelated digital links		2	6			2
	c) <i>Content Evaluation</i>	- Assessing the accuracy of digital information - Assessing the credibility of digital information - Evaluating the suitability of digital			5	7		2

	information content with scientific topics				
d) The ability to integrate knowledge (<i>Assembling and Integrating Knowledge</i>)	- Combining information from various digital sources into a comprehensive understanding - Generating ideas or solutions based on the integration of digital information	4		2	8

Source: Primary Data, 2026

Table 2. Environmental Literacy Grid

Operational Definition	Aspect	Indicators	Questions					Number of Questions
			C2	C3	C4	C5	C6	
The ability to understand, apply, and act with care to consciously protect and preserve the surrounding environment.	a) Understanding Ecological Knowledge (Mastery of basic facts and concepts about the environment).	- Defining basic concepts of ecology and biodiversity - Analysing interactions between components and food chains	9		11			2
	b) Applying cognitive skills (environmental problem-solving abilities).	- Analysing the causes and impacts of environmental problems			12			1
	c) Environmental Awareness (Attitudes and concern for the environment).	- Demonstrating curiosity about environmental issues. - Evaluating the importance of natural resource sustainability		10		13		2
	d) Environmentally Responsible Behaviour (Concrete	- Planning concrete actions based on ecological knowledge					14	1

actions taken by students).

Source: Primary Data, 2026

2.3. Data Analysis Techniques

Data analysis techniques in this study were conducted to assess the quality of the instruments in the form of essay questions that were developed. Data analysis included content validity testing by a team of experts and empirical analysis, namely validity testing, reliability testing, and analysis of the level of difficulty of the questions. Validity testing was used to determine the extent to which the questions were able to measure the predetermined indicators of digital literacy and environmental literacy. Reliability tests were conducted to assess the consistency of the instruments in measuring students' abilities in a stable manner. In addition, difficulty level analysis was used to determine the proportion of difficulty of each item, so that the balance of items in the easy, medium, and difficult categories could be determined. The results of this analysis were used as a basis for revising and refining the instruments so that they could be used to measure the digital literacy and environmental literacy abilities of junior high school students.

2.3.1 Face Validity Analysis

This study used validity analysis by a team of experts to analyse the content, using a 4-point Likert validation questionnaire to reduce uncertain answers. The content validation questionnaire used the following formula:

$$AP = \frac{\text{total validator score}}{\text{highest total score}} \times 100\%$$

Where AP is the percentage

Table 3. Validator Test Criteria

Interval	Category
76% - 100%	Very suitable
51% - 75	Suitable
26% - 50	Not suitable
0% - 25	Very not suitable

Source: Purwanto (2011)

2.3.2 Empirical Analysis

1) Validity Test

The product correlation formula according to Arikunto (2018) is:

$$r_{xy} = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}}$$

Explanation:

- rxy: correlation coefficient between variable X and variable Y, two correlated variables
- N: number of respondents
- X: the average score of X
- Y: average score of Y

A test is considered valid if the results meet the criteria. The criteria in question are parallelism, using the product moment correlation technique proposed by Pearson (Arikunto, 2018).

2) Reliability Test

A test can be said to have a high level of reliability if it is able to provide consistent results. Reliability relates to the level of stability or consistency of the scores obtained from a measurement instrument (Arikunto, 2018). In this study, the reliability of the instrument was analysed using the following formula:

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2} \right)$$

Explanation:

- α = reliability coefficient
- k = number of essay questions
- σ_i^2 = variance of each item score
- σ_t^2 = total variance of test scores

Table 4. Reliability Index

Reliability Index	Category
$0.00 \leq \alpha \leq 0.20$	Very low
$0.21 \leq \alpha \leq 0.40$	Low
$0.41 \leq \alpha \leq 0.60$	Moderate or sufficient
$0.61 \leq \alpha \leq 0.80$	High
$0.81 \leq \alpha \leq 1.00$	Very high

Source: Arikunto (2018)

3) Difficulty Level

A high-quality question is one that has a moderate level of difficulty, neither too easy nor too difficult. An index value close to 0.0 indicates that the question is difficult, while an index value close to 1.0 indicates that the question is very easy. According to Arikunto (2018), the level of difficulty of a question can be determined using:

$$TK = \frac{\bar{X}}{SM}$$

Explanation:

- TK = difficulty level (index) of the essay question
- \bar{X} = the average score obtained by students on a single question
- SM = maximum score on that item

Table 5. Difficulty Index Categories

Reliability Index	Category
0.00 – 0.30	Difficult
0.31 – 0.70	Moderate
0.71 – 1.00	Easy

Source: Arikunto (2018)

3. Results and Discussion

3.1. Research Findings

A. Results of the Analysis of the Digital Literacy and Environmental Literacy Assessment Instrument

Based on the results of expert validation tests conducted by a team of experts and practitioners who are experts in their fields, the results of the digital literacy and environmental literacy instrument on ecology and biodiversity material are presented in Table 6.

Table 6. Content Validation Test Results

No	Component	Percentage	Category
1	Material	88	Very Appropriate
2	Digital Literacy	85	Highly Suitable
3	Environmental Literacy	89	Highly Appropriate
4	Language	83%	Very Suitable
Overall		86.25%	Highly Appropriate

Source: Researcher-Processed Data, 2026

Based on the results above, it is known that the materials, digital literacy, environmental literacy, and language in the test obtained a percentage of 86.25%, which falls into the Very Suitable category. Therefore, it can be concluded that the instrument that has been created is suitable for use in research.

B. Empirical Analysis Results

The results of the empirical analysis, namely the validity test, reliability test, and difficulty index of the essay questions, are explained as follows:

1) Validity Test

The validity test was conducted to determine whether the questions were valid or not. Essay questions that were classified as valid were used as test questions in the research. The results are presented in Table 7.

Table 7. Question Validation Test Results

Question No.	Validity Test		
	Calculated R	Table R	Category
1	0.478	0.349	Valid
2	0.168	0.349	Invalid
3	0.205	0.349	Not Valid
4	0.276	0.349	Not Valid
5	0.073	0.349	Not Valid
6	0.496	0.349	Valid
7	0.622	0.349	Valid
8	0.230	0.349	Invalid
9	0.651	0.349	Valid
10	0.393	0.349	Valid
11	0.592	0.349	Valid
12	0.612	0.349	Valid
13	0.480	0.349	Valid
14	0.706	0.349	Valid

Source: Researcher's Processed Data, 2026

2) Reliability Test

Reliability testing was conducted to assess the level of consistency of an instrument. According to Afifah (2021), an instrument is considered reliable if the reliability coefficient obtained is ≥ 0.60 . Data processing using *Cronbach's Alpha* formula showed a reliability coefficient of 0.6537. Thus, it can be concluded that the instrument used in this study has an adequate level of reliability and is suitable for use.

3) Difficulty Index

The difficulty index analysis aims to identify the level of difficulty of the questions faced by students. The results of the difficulty index calculation for the digital literacy and environmental literacy test questions are presented in Table 8.

Table 8. Results of the Difficulty Index Test for Questions

Question No.	Difficulty Index	Category
1	3.406	Moderate
2	3	Difficult
3	1,437	Difficult
4	1,593	Difficult
5	2,781	Difficult
6	2,531	Difficult
7	1,718	Difficult
8	2,968	Difficult
9	3,125	Moderate
10	2,281	Difficult
11	1.5	Difficult
12	3.125	Moderate
13	2,843	Difficult
14	2,968	Difficult

Source: Researcher's Processed Data, 2026

Based on the results of the above analysis, it can be seen that, on average, the essay questions used by the researcher fall into the difficult category. This was used by the researcher with the aim of measuring the

digital literacy and environmental literacy of junior high school students on the subject of ecology and biodiversity.

3.2. Discussion

Based on the results of the study, it can be seen that the digital literacy and environmental literacy assessment instruments developed have a very high level of content validity, as indicated by the percentage of 86.25% that falls into the "Very Appropriate" category in all components (material, digital literacy, environmental literacy, and language). This finding is in line with research on the development of valid and reliable humanistic literacy instruments in the field of science, where the content validity coefficient is in the high range, meaning that the instruments are declared suitable for use in science education research (Ardani, 2024). This shows that the involvement of expert validators in the content validation process ensures that the questions or items truly reflect the indicators to be measured, in line with the principles of good instrument development according to Borg & Gall. In addition, another study that developed a quiz-assisted digital literacy instrument in secondary schools also found that the content validity value of the instrument was very good with a high S-CVI score, indicating that digital literacy instruments can be measured accurately if they are compiled based on established digital literacy theory (Sintia, et al., 2025). These findings reinforce that a rigorous content validation process improves the quality of instruments, especially in multidimensional literacy such as digital and environmental literacy.

Furthermore, empirical analysis of the items shows that most of the items are valid, but some are invalid. This finding can be explained theoretically by the fact that complex literacy instruments combining digital and environmental literacy require very precise design in terms of item guidance, indicators, and mapping of the skills being measured; if one of the components is not aligned, the validity test results for the item block may decline. A study validating the construct of digital literacy using the CFA approach also shows that all items proven to be valid are those that can theoretically represent the dimensions of digital literacy being measured, while items that do not meet the factor loading criteria should be revised or deleted (Nugrahini, 2025). This indicates that instruments measuring digital literacy and other contextual aspects do require strong empirical evaluation through advanced statistical methods. The success of valid instruments in this study generally supports the hypothesis that most instruments are constructually appropriate, but the existence of invalid questions reflects the challenge of ensuring the operational suitability of indicators with respondents' actual answers (Zayrin, et al., 2025).

The reliability results of the instrument, which achieved a *Cronbach's Alpha* value of 0.6537, are also in line with the literature, which considers a reliability value above 0.60 to be adequate for educational research instruments, especially when measuring complex competencies such as digital literacy and environmental literacy. Similarly, research on the development of digital literacy instruments in senior high schools shows that good item reliability ($\alpha > 0.684$) indicates high internal consistency, which means that the items are generally stable in measuring the same construct (Febliza & Oktariani, 2020). These reliability findings are important because reliable instruments indicate that the literacy measurements taken can be trusted for various subsequent interpretations of the results, for example, in testing group differences or correlations with other variables. Meanwhile, the difficulty index analysis shows that the majority of questions are in the difficult category for students to answer, which means that the instrument is able to challenge students at a high level of thinking, an important feature in 21st-century skills-based literacy *assessments* such as digital and environmental literacy. This condition is in line with research (Siagian, et al., 2023) that designed science literacy-based instruments with varying levels of difficulty to map students' high abilities in environmental learning, and showed that more challenging questions were able to reveal students' critical thinking abilities more clearly than questions that were too easy.

Implicitly, these findings indicate that valid and reliable literacy assessment instruments have great potential for use in educational learning and evaluation, and can assist teachers in designing more targeted instruction to improve students' digital and environmental literacy. This is particularly relevant in efforts to strengthen 21st-century literacy in secondary schools, where digital and environmental literacy are an important part of the science education curriculum. If the instrument is further developed based on advanced construct validation (e.g., CFA or Rasch), it could even be used as a standard instrument in broader educational research.

3.3. Connection to Research Objectives

The results of this study show strong relevance to the research objectives formulated in the introduction, namely to develop and test the feasibility of instruments for assessing the digital literacy and environmental literacy of junior high school students on the subject of ecology and biodiversity. The content validity findings, which were in the highly appropriate category, prove that the developed instrument has met the substance, literacy indicator, and language standards required to accurately measure students' literacy abilities. Furthermore, the empirical validity and reliability test results show that most of the items are able to measure the intended construct consistently, so that this instrument can be used as a reliable measuring tool. The difficulty index analysis, which was dominated by the difficult category, also answered the research question regarding the instrument's ability to measure literacy at a high level of thinking, which has rarely been focused on in assessments at the junior high school level. Thus, the findings of this study not only answer the research objectives but also fill the gap in previous studies, which tended to focus on partial literacy measurement and lacked integration between digital and environmental aspects. The resulting instrument is expected to be a relevant assessment alternative for 21st-century literacy demands.

4. Conclusion

The conclusion of this study is that the digital literacy and environmental literacy assessment instruments on ecology and biodiversity material have met the eligibility criteria, in terms of highly appropriate content validity and adequate reliability. This instrument is effective in measuring students' literacy skills at a high level of thinking. The limitation of this study lies in the dominance of difficult questions. Further research is recommended to develop variations in difficulty levels so that the instrument is more comprehensive.

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