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Developing a Digital Tool to Assess Students' Sustainability Literacy in Wetland Contexts

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Abstract: This study develops a digital assessment instrument on the Socrative platform to measure high school students' sustainability literacy on global warming within wetland ecosystems, supporting SDG 13 (Climate Action). Using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), the research involved: teacher needs analysis, design of 50 wetland-contextualized multiple-choice questions, validation by four environmental experts and three teachers, and trials with 125 students. Content Validity Ratio (CVR ≥ 0.99) confirmed 32 items as valid; 18 were revised for contextual alignment. The instrument showed very high reliability (Cronbach's Alpha = 0.977), with 25 questions demonstrating good discrimination. While Socrative enhanced interactivity, teacher competence in digital tools requires improvement. The innovation lies in integrating understudied wetland contexts with sustainability literacy assessments, bridging technology (Socrative), local ecology, and SDG principles. Findings emphasize contextualized digital tools as catalysts for climate education and educator capacity building.

Keywords: Assessment; Sustainability literacy; Wetland.

Introduction

Climate change is an urgent global crisis that is already having significant impacts on environmental sustainability. One of the ecosystems most vulnerable to these impacts are wetlands, which play an important role as carbon stores, biodiversity buffers, and regulators of the regional water cycle and climate. Indonesia, as a country with a significant wetland area, stores about 14% of global carbon stocks in these ecosystems. However, more than 50% of the nation's wetlands have been degraded due to land conversion, pollution, forest fires, and increasing global temperatures (Agustina et al., 2024; Budianto & Amaliyah, 2017). The IPCC report (2023) states that wetland restoration could potentially contribute 10-15% of global greenhouse gas emission reductions per year, making it one of the most effective ecosystem-based mitigation strategies.

Unfortunately, the urgency of wetland protection has not been fully integrated into the national education system, particularly in the context of strengthening sustainability literacy. Sustainability literacy refers to the ability to understand the complexity of environmental and social issues, think systemically, and make responsible decisions for the future of the planet (Chuenchum et al., 2024). On the other hand, the low science literacy of Indonesian students is a serious warning for the future of the nation. Based on the latest PISA report, Indonesian students' science scores only reached 398, far below the OECD average of 489 (Hewi & Saleh, 2020). Although this low achievement is caused by various factors, one aspect that is often overlooked is the lack of assessment instruments that are contextual and relevant to local environmental issues, such as wetland degradation. Without an assessment approach that is rooted in the reality of the surrounding environment, students are less likely to have an affective

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or cognitive attachment to sustainability issues that are crucial to their own region (Fricticarani et al., 2023; Utami et al., 2022).

Previously developed assessment instruments have indeed integrated local wisdom (Himmah, 2020; Ibrahim, 2014) and digitalization (Munazar & Qomarudin, 2021), but none have specifically linked wetland ecosystems with global warming issues in a series of sustainability literacy-based assessments, let alone using an interactive digital approach. This is where the novelty of this research lies: the development of an assessment instrument based on the local context of wetlands, linked to the issue of global warming, and implemented through the Socrative digital platform that allows real-time feedback and efficient tracking of student abilities.

The need for this instrument development is reinforced by the results of a needs analysis of 27 high school physics teachers, which showed that 33% of students were not familiar with the characteristics of wetlands, and 41% of teachers did not feel competent in designing sustainability literacy-based assessments. In addition, only 55% of teachers had used digital platforms for evaluation, mostly limited to Google Forms. These results indicate a gap between the curriculum, teachers' capacity and the need for contextualized and sustainability-oriented learning. In this context, the selection of the Socrative platform is not merely a technology preference, but a direct response to teachers' needs for a tool that is easy to use, able to provide immediate feedback and support more meaningful learning.

To address this challenge, this study developed a digital assessment instrument using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The validity and reliability of the instrument were tested through Tessmer's formative evaluation, which includes five systematic stages: self-evaluation, expert review, one-on-one trial, small group test, and field test (Tessmer, 2013). The use of this approach allowed for an instrument development process that was iterative, reflective, and responsive to feedback from various parties. Thus, the main contribution of this research lies not only in the development of measuring instruments, but in systematic efforts to link global knowledge (global warming issues) and local context (Indonesian wetlands), integrate education for sustainable development (ESD) into concrete and measurable assessments, and empower teachers and students in utilizing digital technology as part of climate education solutions.

This instrument is expected to be a practical and scientific tool to improve the sustainability literacy of high school students, while supporting the implementation of the Sustainable Development Goals (SDGs), especially point 13: Handling Climate Change, through contextual, relevant and evidence-based education.

Method

This study used a Research and Development (R&D) approach with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model commonly used in instructional design (Akhsan et al., 2022; Bashooir & Supahar, 2018). This model was chosen because it is systematic, flexible, and allows for iterative testing at each stage of product development. The stages of the ADDIE model in this study are described as follows:

Analysis: Conduct a needs study through questionnaires to 27 high school physics teachers to determine the level of understanding of students and teachers regarding global warming, wetlands, and the use of digital platforms in assessment. Design: Developing sustainability literacy indicators and question grids based on the context of wetlands integrated with global warming issues. Development: Developed 50 multiple-choice questions and integrated them into the Socrative platform. The questions were validated by experts and teachers using the CVR and CVI approaches. Implementation: Conducting instrument trials on XI grade students of SMA Negeri 1 Madang Suku I. Evaluation: Assessing the quality of the instrument based on content validity, internal reliability, question difficulty level, and differentiating power. The formative evaluation was conducted following Tessmer (2013) five-stage formative evaluation framework as shown in Table 1.

Content validation was carried out using the Content Validity Ratio (CVR) from (Lawshe, 1975), which was calculated using the Formula 1.

$$CVR = \frac{ne-(\frac{n}{2})}{\frac{n}{2}} \tag{1}$$

Description:
CVR = content validity rasio
n_e = number of validators who stated essential
n = total number of validators

Table 1. Tessmer's Evaluation Stages

Formative Evaluation Stage	Subjek	Explanation
Self-Evaluation	Researcher	Internal review of the initial quality of the instrument and the suitability of the indicators to the sustainability literacy objectives.
Expert Review	4 environmental education expert lecturers and 3 physics teachers	Content validation was conducted on 50 questions using the Content Validity Ratio (CVR) approach per item. CVI was calculated as the average CVR of all valid items.
One-to-One Evaluation	3 students	In-depth interviews and discussions to test the clarity of language and context of each question.
Small Group Evaluation	9 students of grade XI SMA NEGERI Madang Suku I	Limited pilot test to evaluate the workflow of the instrument on the Socrative platform and technical effectiveness.
Field Test	125 grade XI students from SMA NEGERI Madang Suku I	Full-scale testing to analyze reliability, difficulty, and discriminating power.

Based on Lawshe's updated standards (Ayre & Scally, 2014), for 7 panelists, the minimum CVR value is 0.99 to be statistically significant at α = 0.05. Items that did not reach this value were declared invalid and revised or deleted. Next, the Content Validity Index (CVI) was calculated as the average CVR of the valid items, reflecting the overall content validity of the instrument.

The score of the test evaluation test results is then carried out reliability to measure whether the test question instrument used has met the standards and is suitable for use. At this stage using the help of SPSS software version 25.0 for windows or ministep software and the technique used is to see Cronbach's Alpha in the Summary Statistic results (Masrukhin, 2006). The question items are considered reliable if they meet the criteria for the correlation coefficient of instrument reliability, which can be seen in Table 2.

Table 2. Reliability Criteria (Novia et al., 2020)

Criteria Size	Criterion
0.00-0.20	Very Low
0.21-0.40	Low
0.41-0.60	Medium
0.61-0.80	High
0.81-1.00	Very High

The instrument is declared reliable if the Cronbach's Alpha value is ≥ 0.41. According to Budiantoro (Srirahayu & Arty, 2018). the basis for decision making in this test is to compare the Sig value. (2-tailed) with a probability of 0.05. The level of difficulty is the degree of difficulty of a question item expressed in number form (Saputri et al., 2023).The difficulty index (P) is calculated by the following formula (Saputri et al., 2023).

$$P = \frac{B}{JS} \quad (2)$$

Where:
P = Difficulty Index
B = The number of students who answered the question correctly
JS = Total number of students taking the test

The P value ranges from 0 to 1, with the following interpretation:

Table 3. Criteria for Problem Difficulty (Saputri et al., 2023)

Criteria Size	Criterion
< 0.25	Too difficult
0.25 – 0.75	Medium
>0.75	Too easy

Differentiating power analysis is used to assess the extent to which each item is able to differentiate students with high and low abilities. The analysis was conducted using SPSS software to simplify the calculation. Differentiating power has several criteria, the criteria for differentiating power can be seen in table 4.

Table 4. Criteria for Distinguishing Power (Arikunto, 2015)

Criteria Size	Criterion
0.00-0.19	Not good
0.20-0.39	Enough
0.40-0.69	Good
0.70-1.00	Very good
Negatif	Bad

Table 5. Sustainability Literacy Question Grid

Indicator	Sustainability Literacy Indicators	Aspects	Information
Humanity and sustainable ecosystems on planet earth.	1. Ecological Perspective: where we are, and why sustainability is both an urgency and an opportunity.	Environment	7 item
	2. Social Perspective: where we are (demographics, inequality, gender equality, education, laws, policies) and why sustainability is both an urgency and an opportunity	Social	6 item
Human-constructed local and global systems to address societal needs	3. Social and governance structures in global and local governance; paradigms; positive outcomes with negative impacts; laws; how organizations work; land use; etc.	Social	7 item
	4. In local and global social and governance structures, focusing on: education and culture	Social	1 item
	5. Local and global economic systems; paradigms; positive outcomes with negative impacts; laws; how organizations work; land use; gender equality; etc.	Economics	5 item
Transition to sustainable living	6. How to initiate, sustain and accelerate system change	Environment	4 item
	7. Concepts, Tools, Frameworks, more from NGOs or smaller networks	Environment	3 item
	8. Examples and ideas that can be learned from: case studies of successes or failures; technological, strategic, or social innovations	Social	3 item
Role of self to shape and maintain individual and systemic change	9. How can one realize their role and impact? (one could be an individual, organization etc.)	Environment	3 item
	10. How does one act efficiently to create individual and system change?	Social	2 item
Individual Skills	11. Capacity for empathy, compassion, solidarity; future-oriented and strategic thinking	Economics	2 item
	12. Network; communication skills; Building an effective coalition for systemic change	Economics	1 item
Mindset	13. Respect and care for the community of life, now and in the future	Economics	2 item
	14. Holistic versus mechanistic worldview	Environment	3 item
	15. Golden rules (treat others as you would like them to treat you)	Economics	1 item

Result and Discussion

The results of content validation showed that of the 50 questions developed, 32 items met the valid criteria based on the Content Validity Ratio (CVR) value calculated from seven validators, consisting of four environmental expert lecturers and three physics teachers. The validity determination used a minimum CVR threshold of 0.622, as determined by Ayre & Scally (2014) for seven validators. Previously, the CVR ≥ 0.99 threshold used in the method was a conservative value and less in line with standard statistical guidelines. Thus, the reinterpretation of the validity values per item showed that most of the items that were considered invalid originally were actually within statistically acceptable validity limits. Furthermore, the Content Validity Index (CVI), calculated as the average of the CVR values of all valid items, was found to be 0.982. This value indicates that overall, the instrument has an excellent level of content validity and is in accordance with the sustainability literacy construct being measured.

This stage is useful to validate the instrument as well as to identify and correct errors in the developed product (Annisa Wudda et al., 2024). The results of products that have been validated can be seen in table 6.

Table 6. Result Validity

Question	CVR	Information
1-6	1.0	Valid
7,8	0.71	Not Valid
9-12	1.0	Valid
13,14	0.71	Not Valid
15-20	1.0	Valid
21	0.43	Not Valid
22, 23	0.71	Not Valid
24	0.43	Not Valid
25	1.0	Valid
26	0.71	Not Valid
27,28	1.0	Valid
29	0.71	Not Valid
30-34	1.0	Valid
35	0.71	Not Valid
36	1.0	Valid
37	0.71	Not Valid
38	1.0	Valid
39	0.71	Not Valid
40-43	1.0	Valid
44,45	0.71	Not Valid
46	1.0	Valid
47	0.71	Not Valid

Question	CVR	Information
48	1	Valid
49.50	0.71	Not Valid

Table 6 shows that there are 18 questions that have a CVR value below 0.99 and 32 questions that have a value above 0.99. This shows that there are 32 valid questions and 18 invalid questions so that the questions used in the next stage consist of 32 questions. Examples of invalid questions include Questions 7, 8, 13, 14, 21-24, 26, 29, 35, 37, 39, 44-45, 47, 49-50. The cause of invalidation was generally due to incompatibility with sustainability literacy indicators or the wetland context. Invalid questions were revised or deleted before the field test. The validity test of literasi suistainabillity assessment instrument was carried out, followed by a reliability test. The reliability test of literasi suistainability assessment instrument was carried out with the help of the SPSS application. The results of the instrument reliability test can be seen in Table 7.

Table 7. Reliability Results

Cronbach's Alpha	N of Items
0.977	32

The results of the internal consistency test using Cronbach's Alpha showed a value of 0.977, which falls into the very high category. While this reflects excellent inter-item stability and coherence, reliability values that are too close to 1 can also be an indication of item redundancy, which is when several items measure the same competency or literacy aspect repeatedly. This redundancy can reduce the efficiency of the instrument and reduce the variation in student responses. Therefore, refinement of the instrument at a later stage needs to focus on reviewing and simplifying items that are similar in context and substance, to ensure that each item contributes unique and important information to the assessment of sustainability literacy. Furthermore, the level of difficulty test was carried out, the results of the level of difficulty can be seen in Table 8.

Table 8. Level of difficulty of the Field Test

Questions	N		
	Valid	Missing	Mean
Question 1	125	0	0.8160
Question 2	125	0	0.6960
Question 3	125	0	0.6240
Question 4	125	0	0.6960
Question 5	125	0	0.8640
Question 6	125	0	0.5360
Question 7	125	0	0.8080
Question 8	125	0	0.9120
Question 9	125	0	0.8080
Question 10	125	0	0.9200
Question 11	125	0	0.7040
Question 12	125	0	0.8720
Question 13	125	0	0.9280
Question 14	125	0	0.8960
Question 15	125	0	0.9440
Question 16	125	0	0.8400
Question 17	125	0	0.8880
Question 18	125	0	0.6160
Question 19	125	0	0.8000
Question 20	125	0	0.8880
Question 21	125	0	0.7360
Question 22	125	0	0.8560
Question 23	125	0	0.8240
Question 24	125	0	0.6720
Question 25	125	0	0.7040
Question 26	125	0	0.5600
Question 27	125	0	0.8560
Question 28	125	0	0.8145
Question 29	125	0	0.3920
Question 30	125	0	0.9120
Question 31	125	0	0.5520
Question 32	125	0	0.3680

The analysis of the level of difficulty showed that 64% of the total items were in the medium difficulty category (difficulty index P = 0.25-0.75), while 36% of the items were classified as too easy (P > 0.75), and there were no items in the too difficult category. This distribution is ideal for the purpose of measuring the sustainability literacy of upper secondary students, which is to identify basic to intermediate understanding. However, the absence of questions with a high level of difficulty may limit the instrument's ability to distinguish students who have an advanced understanding of sustainability issues. Therefore, further development should be prepared by adding some items with a higher level of complexity, especially those that measure critical thinking and problem-solving skills in an environmental context. Then, a differentiating power test is carried out, the results of the differential power can be seen from the Corrected Item-Total Correlation which can be seen in Table 9.

Table 9. Hasil Intrepretasi Daya Beda Field Tes

Question	Corrected Item-Total Correction	Interpretation	Question	Corrected Item-Total Correction	Interpretation
1	0.273	Enough	17	0.629	Enough
2	0.341	Enough	18	0.363	Enough
3	0.407	Good	19	0.640	Good

Question	Corrected Item-Total Correction	Interpretation	Question	Corrected Item-Total Correction	Interpretation
4	0.329	Enough	20	0.667	Good
5	0.404	Good	21	0.591	Good
6	0.282	Enough	22	0.596	Good
7	0.271	Enough	23	0.527	Good
8	0.479	Good	24	0.536	Good
9	0.484	Good	25	0.575	Good
10	0.672	Good	26	0.535	Good
11	0.269	Enough	27	0.438	Good
12	0.487	Good	28	0.483	Good
13	0.485	Good	29	0.361	Enough
14	0.569	Good	30	0.534	Good
15	0.591	Good	31	0.401	Good
16	0.660	Good	32	0.387	Enough

Some sample questions were further examined to understand the characteristics of difficulty and discriminating power. For example, question numbers 10 and 15 were classified as very easy (P > 0.90) because they contained explicit questions about the function of wetlands in sequestering carbon and the direct impacts of global warming, which are likely to be easily recognized by students. In contrast, question number 29, although it had a medium level of difficulty (P = 0.392), only had "fair" discriminating power because it discussed local policies that students may be less familiar with. Of the 32 items used in the field test, 25 items had good discriminating power (r ≥ 0.40), while the rest were in the moderate category (r = 0.20-0.39), indicating that most items were able to effectively differentiate between high and low ability students.

Discussion

Instrument validation in this study involved seven experts, consisting of four environmental lecturers and three physics teachers. The dominance of experts from the field of ecology can lead to ecological bias, namely the tendency to emphasize the biophysical and technical aspects of sustainability, such as carbon sequestration, land degradation, and the ecological impacts of global warming, compared to the social and economic dimensions. This can be seen from the structure of the questions, which relatively evaluate students' understanding of the role of wetlands in the carbon cycle, but few touch on social issues such as climate justice, local community participation, or the socio-economic impacts of wetland degradation (Décamps et al., 2017). If not corrected, this bias could lead to a partial measurement of sustainability literacy and not reflect the systemic approach as emphasized in education for sustainable development (ESD). Therefore, the involvement of experts from social science or public policy disciplines is highly recommended in the next stage of validation to make the content coverage more holistic and representative of the overarching dimensions of sustainability. Furthermore, the reliability test using Cronbach's Alpha in a small group (9 students) resulted in a value of α = 0.977, which is classified as "Very High". This value indicates exceptional internal consistency of the instrument, but also hints at the possibility of item redundancy, where some questions may be too similar or measure the same concept. This needs to be taken into consideration for refining the instrument to make it more efficient without sacrificing reliability (Putri, 2020).

To further understand the characteristics of difficulty and discriminating power, some items were analyzed in depth. For example, item number 10, which was classified as very easy (P = 0.92), asked students to mention the main function of wetlands in absorbing carbon dioxide. This question is informative and direct, and often appears in textbooks and class discussions, so it can be easily answered by the majority of students. The same applies to question 15 (P = 0.944), which asks about the impacts of global warming on wetlands, such as sea level rise and changes in biodiversity. Both questions, although important, had low challenge. In contrast, question 1 had a medium level of difficulty but low discriminating power (r = 0.273), as it only asked for the definition of sustainability literacy, without encouraging integration of concepts between fields. Question 29 (P = 0.392; r = 0.361), which related to the implementation of local policies in wetland protection, had moderate discriminating power because not all students had contextual knowledge of environmental regulations in their area. Reviewing the content of questions like this is important to harmonize the level of difficulty, differentiating power, and cognitive depth to be measured (Siregar & Rozi, 2024).

The integration of the wetland context and the use of the Socrative platform are the hallmarks of this instrument. Digital technology enables real-time feedback, automated data analysis and increased student engagement through interactive formats. However, the finding that 41% of teachers still lack competence in designing digital assessments indicates the need for technical training to maximize the potential of this platform in daily learning. This study has limitations, including the pilot sample being limited to one school (SMA Negeri 1 Madang Suku 1) and the number of validators being dominated by environmental experts. This could potentially affect the generalizability of the results and the balance of socio-economic perspectives in the instrument. In addition, the high Cronbach's Alpha value raises questions about possible redundancy of items that need to be further evaluated (Rini & Rufi'i, 2023; Slamet & Wahyuningsih, 2022). Overall, the instrument has met good validity and reliability standards, with great potential to support local context-based sustainability literacy education. However, refinements on variations in difficulty, differentiation, as well as teacher training are crucial steps to increase its effectiveness in achieving the SDGs goals, especially point 13 on addressing climate change. Further research with wider sample coverage and diversification of validators is recommended to test the adaptability of the instrument in various geographical and socio-cultural contexts.

In the validation process, it should be noted that the dominance of the validator's background from the environmental field has the potential to produce bias, namely the tendency to overemphasize the ecological aspects of the instrument. This may neglect the social and economic dimensions of sustainability literacy, which are also important as per the UNESCO (2017) framework. As a result, some questions may focus too much on issues such as carbon sequestration and land degradation, without proportionally exploring aspects of community roles, social inequality or sustainable economies. This potential bias should be a concern in the redesign of the instrument to ensure that the assessment reflects a holistic approach to sustainability.

This instrument was explicitly developed to support Sustainable Development Goals (SDG) point 13, namely "Action on Climate Change." This connection is shown through the items that measure students' understanding of the concepts of climate change mitigation and adaptation in the context of wetland ecosystems. For example, some questions are designed to assess whether students can: (1) explain how wetlands play a role in absorbing carbon dioxide emissions; (2) identify the impacts of increasing global temperatures on the water cycle and biodiversity; and (3) suggest local school- or community-based solutions for wetland conservation. These items not only test conceptual knowledge, but also encourage students to think critically about local climate action as part of global responsibility, in line with SDG indicator 13.3, which is "enhancing education, awareness, and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning." As such, the instrument is able to bridge between national curricula, local contexts and global agendas within the framework of sustainability education.

Conclusion

This research successfully developed a digital assessment instrument based on the Socrative platform to measure the sustainability literacy of high school students in the context of wetlands and global warming. Of the 50 questions developed, 32 were declared valid based on CVR values ≥ 0.622 (according to the number of 7 validators), and the overall CVI reached 0.982. A total of 10 out of 18 initially invalid items were revised and reinserted after meeting the criteria, while 8 items were deleted. The reliability of the instrument was very high (Cronbach's Alpha = 0.977), but it showed indications of item redundancy that needed to be simplified to be more efficient and not to cause boredom in students. The distribution of item difficulty levels was in the medium category (64%), in line with the aim of measuring basic to intermediate understanding, although it was not optimal in distinguishing high ability students. Potential content bias arises due to the dominance of validators from the environmental field, so that the socio-economic aspects of sustainability literacy are relatively underrepresented. This instrument directly supports the achievement of SDG 13 (Climate Action) by measuring students' understanding of mitigation, adaptation, and the role of wetlands in the context of climate change. Further research is recommended to: (1) develop questions with more varied levels of difficulty and differentiation; (2) enrich the social and economic content of sustainability; and (3) develop teacher training related to the utilization of digital assessments based on local contexts.

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