

Developing Instruments for Measuring the Level of Environmental Sustainability Awareness in Chemistry Learning

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Abstract

This study aims to develop a sustainable environmental awareness instrument and test its quality through validity and reliability. This is a development study that develops a sustainable environmental awareness instrument in chemistry learning through revision techniques. The sustainable environmental awareness scale instrument consists of three categories, namely sustainable practice awareness related to activities carried out consistently and sustainably in relation to the environment, behavioral and attitudinal awareness related to understanding the application of environmentally friendly actions, and emotional awareness that shows emotional sensitivity regarding responsibility for environmental issues. Based on the research conducted, a sustainable environmental awareness instrument was developed with 21 statement items that have been declared valid and reliable with a Cronbach's Alpha value of 0.823. Therefore, the developed instrument is suitable for use in further research.

Keywords: Chemistry learning, Environmental awareness, Sustainable development goals

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INTRODUCTION

Environmental issues such as climate change pose a threat to every country and have become a major topic in international relations studies. One significant impact of climate change is the depletion of natural resources. In addition, human activities contribute to environmental destruction (Nugroho, 2018). Because all human activities are closely related to the environment (Kusumaningrum & Wijayanto, 2020), understanding environmental issues is essential. A person's understanding of environmental issues is reflected in environmental literacy, which is the ability to understand, apply, and participate in complex environmental issues. Environmental literacy also involves understanding environmental concepts and principles and the ability to interpret scientific information related to the environment (Rokhmah & Fauziah, 2021). Through environmental literacy, awareness and sustainable actions to protect and preserve the environment can be developed (Erlistiani et al., 2020).

Since the 1972 Stockholm International Conference, several countries and the United Nations (UN) have been working to prevent further environmental damage. At the

international level, the UN established 17 Sustainable Development Goals (SDGs) to support global development. One of these goals is to support environmental conservation by 2030 (Lasekan et al., 2023). The use of advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), and other digital innovations can help manage resource use and minimize environmental impact in support of the SDGs (Ramírez-Márquez et al., 2024).

Environmental awareness refers to an individual's understanding of how to protect and preserve the environment by recognizing activities negatively impact it. Individuals with environmental awareness take steps to address environmental challenges and maintain the balance of the earth's ecosystem, such as reducing energy consumption and supporting environmentally friendly practices (Noviyanti et al., 2017). Sustainable awareness is categorized into three dimensions: (1) awareness of sustainable practices related to activities carried out consistently and sustainably in relation to the environment; (2) awareness of behavior and attitudes related to understanding how to implement environmentally friendly actions; and (3) emotional awareness, which shows emotional

sensitivity regarding responsibility for environmental issues (Hassan et al., 2010).

In Indonesia, SDG principles have been incorporated into various national policies through the national development plan, particularly through education for sustainable development (ESD) (Adila et al., 2025; Aini & Sari, 2024). However, in practice, learning that adopts SDG principles has only been implemented in a limited number of provinces. This is due to factors such as school accessibility, low capacity, and suboptimal performance of educators (Ratnasari & Nugraheni, 2024). In fact, the implementation of ESD plays an important role in building understanding and awareness of environmental, social, and economic issues (Clarisa et al., 2020).

Chemistry learning has significant potential to support the implementation of ESD as it can be used to raise issues related to the environment. Chemistry education not only emphasizes conceptual understanding but also the application of concepts to solve problems in everyday life, including environmental issues (Hanifha et al., 2023). Learning approaches that link sustainability issues can encourage students to become more active and reflective regarding environmental problems (Pratama et al., 2025). Furthermore, practical activities that consider environmental impacts and sustainability principles can enhance students' environmental awareness, for example through green chemistry-based practical work (Kamilah & Louise, 2025). Through the integration of environmental issues in learning, students can also develop critical thinking, collaboration skills, the ability to accept and negotiate ideas, and problem-solving in everyday life (Rahmawati, 2018). However, learning is often carried out conventionally, with a focus on mastering learning content and memorizing information without applying concepts in real life (Rahmawati et al., 2024; Ulfa et al., 2023). This is evidenced by the fact that students' environmental awareness remains at low (Arofah & Pujilestari, 2020; Nasution, 2016) and moderate levels (Qodriyanti et al., 2022). The low level of environmental awareness among students may be attributed to the fact that some teachers still focus on cognitive competencies (Perkasa et al., 2017) and the low level of curiosity and understanding of students regarding environmental issues (Permatasari et al., 2024).

Noncognitive factors supporting sustainable chemistry learning, particularly in shaping students' attitudes and perseverance,

depend on individual characteristics and attitudes that contribute to learning success (Abukasim et al., 2025). These findings reinforce the need for instruments that have been tested to analyze levels of sustainable environmental awareness in terms of validity and reliability. Validity is an important aspect of instrument development, which indicates that the instrument accurately measures an object. Therefore, validity shows the reliability of the instrument in the measurements taken (Yusuf, 2018). In addition, an instrument must demonstrate reliability, meaning that it is able to show consistency in measuring different samples in different places and times (Busnawir, 2012).

Another important consideration when developing instruments is the type of statement items used, including positive and negative items in questionnaires or measurement scales. This condition is related to the acquiescence effect (set-yes), which is an individual's tendency to offer an affirmative answer to a presented statement regardless of its content. Therefore, a questionnaire or measurement instrument should include both positive and negative statement items. Negative statement items are commonly used to assess the consistency of respondents' answers (Hinz et al., 2007). Instruments may also need to be revised before use to ensure they include adjustments to the social, cultural, and curricular contexts so that the constructs being measured are in accordance with the conditions of the respondents.

Based on existing data on students' environmental awareness levels, there is a need for an instrument that can accurately and comprehensively measure sustainable environmental awareness levels. Such instrument must cover all categories or aspects of sustainable environmental awareness and has been tested theoretically and empirically, to ensure that it meets the requirements of a valid and reliable instrument. Accordingly, this study aims to develop a sustainable environmental awareness instrument and evaluate its quality in terms of validity and reliability.

METHOD

Development model

This research is a developmental study aimed at producing a product in the form of an instrument to measure students' sustainable environmental awareness in chemistry lessons. The development model used in this study,

according to Borg and Gall (1983), consists of four simplified stages: 1) initial investigation, 2) design, 3) trial, evaluation, and revision, and 4) implementation.

In the initial stage, the researcher conducted a preliminary study to explore and review theories and previous research findings on sustainable environmental awareness. In the design stage, the researcher drafted a sustainable environmental awareness instrument and designed a test to be implemented. In the trial, evaluation, and revision stages, validity tests and pilot tests of the developed instrument were conducted. The data obtained were used for further analysis. If the results indicated that the instrument was inadequate, it could be revised and retested until a final instrument met its feasibility. In the implementation stage, the validated instrument could be used for further research.

Development procedure

Several steps were undertaken in developing the sustainable environmental awareness instrument for chemistry learning, including initial investigation, design, trial, evaluation, revision, and implementation. At the initial investigation, a sustainable environmental awareness instrument was developed based on sources that had been sought and reviewed by the researchers. Several sources have identified aspects for developing a sustainable environmental awareness instrument, such as knowledge, attitudes, and behavior/actions (Kencanasari et al., 2019 and Tampubolon et al., 2024). The aspects in these two sources are reinforced by research by Hassan et al., 2010, which used the concept of sustainable development, with aspects/categories consisting of: 1) awareness of sustainable practices, related to activities carried out consistently and

sustainably in relation to the environment; 2) awareness of behavior and attitudes, related to understanding how to implement environmentally friendly actions; and 3) emotional awareness, which indicates emotional sensitivity regarding responsibility for environmental issues. The instrument produced by Hassan et al., 2010, was obtained through synthesis techniques based on preliminary studies, data collection using survey techniques, data analysis, and Pearson correlation analysis to determine the strength of correlations between items.

At design section, all identified aspects of environmental awareness served as the basis for developing the sustainable environmental awareness instrument. The primary reference in this study was the instrument developed by Hassan et al. (2010), which was developed using a synthesis technique. The items in the present study were developed based on aspects of sustainable environmental awareness and were adapted to the Indonesian context. The development of statement items also required careful attention to the type of statement (positive or negative) to minimize the acquiescence effect and bias, as students may tend to respond to statements without carefully reading the statements, and to monitor and ensure the consistency of the sample in the answers given.

The development of statement items in the instrument was carried out by adding negative statement items. This provided advantages such as reducing response bias, enhancing construct validity, assessing the consistency of respondents' understanding, and improving instrument reliability. The instrument was developed as a 5-point Likert scale. The resulting draft represented the first version of the instrument. The outline of the first draft of the instrument are presented in Table 1

Table 1. The specifications for the environmental sustainability awareness instrument

Category	Type of Statement	Item Number
Sustainability practice awareness	Positive	4, 13, 14, 18, 19
	Negative	5, 20
Behavioral and attitude awareness	Positive	1, 9, 10, 12, 16, 17
	Negative	7, 11
Emotional awareness	Positive	3, 6, 8, 21
	Negative	2, 15

The validity test of the developed instrument consisted of theoretical and empirical validity. Theoretical validity was assessed through expert judgment to examine the content

and refine the draft instrument developed in terms of substance, construction, and language. The instrument developed in this study was assessed by designated expert lecturers. After the

evaluation was completed, the researchers revised the instrument based on the suggestions and input provided before proceeding to further testing.

The revised draft was then piloted on a predetermined sample to evaluate its validity and reliability. The pilot test involved 70 12th-grade students from a public high school in Yogyakarta. The sample criteria included students majoring in Mathematics and Natural Sciences, aged 18-19 years, who had basic knowledge of sustainable environmental awareness. A simple random sampling technique was utilized to ensure that each individual had an equal opportunity to be selected as a participant.

Data obtained from expert judgment were analyzed descriptively, while data generated from the field trial were analyzed using Pearson's product-moment, exploratory factor analysis (EFA), and Cronbach's alpha. Item validity was determined by comparing the calculated r value with the r table. If the calculated r value was greater than r table, the item was considered valid. The reliability of instruments was assessed using Cronbach's alpha coefficient. The closer the reliability coefficient (r) to 1, the higher the consistency of the instrument. Reliability coefficients with an r value greater than or equal to 0.800 are categorized as very high reliability, while lower r values are classified into high, moderate, low, or very low categories (Forester et al., 2024). The analysis results determined the feasibility of the instrument for implementation in further research.

The implementation stage involved administering the final instrument after it was declared suitable for measuring students' awareness of environmental sustainability. The participants selected for implementation were students majoring in Mathematics and Natural Sciences, with the sample size determined according to the type and purpose of the research.

RESULT AND DISCUSSION

The sustainable environmental awareness instrument developed for chemistry learning is intended to measure the level of sustainable environmental awareness among students across three areas: (1) awareness of sustainable practices, (2) awareness of behavior and attitudes, and (3) emotional awareness. The developed instrument was then tested for validity and reliability to determine its quality. The validity testing conducted in this study consisted of theoretical validity and empirical validity. These procedures were performed to ensure that the instrument accurately measured the intended construct and demonstrated satisfactory consistency. Validity and reliability testing are essential when developing a new instrument or updating and refining an instrument from previous studies.

Theoretical validity was determined through expert judgment conducted by an expert lecturer. This process aimed to assess the instrument in terms of substance, construction, and language. Expert judgment contributed to optimizing instruments to accurately measure sustainable environmental awareness (Udil et al., 2023). The aspects assessed in the theoretical validity testing included 1. statement suitability (statements are consistent with indicators and items are relevant to the construct being measured), 2. construction aspects (statements are clearly formulated and statements are coherent and systematic), and 3. language aspects (statements are logical and easy to understand and statements use language that complies with Indonesian language rules. Expert judgment assessed these aspects for each item in the sustainable environmental awareness instrument. The results of the theoretical validation are presented in Table 2.

Table 2. Theoretical validation result by expert judgment

Assessment Aspects	Desision	Validation Result
Statements are consistent with indicators	Fulfilled	The instrument is suitable for use without revision
Relevance of items to the construct being measured	Fulfilled	
Statements are clearly formulated	Fulfilled	
Statements are coherent and systematic	Fulfilled	
Statements are logical and easy to understand	Fulfilled	
Uses language that complies with Bahasa rules	Fulfilled	

Based on the results of the theoretical validity testing, the expert concluded that the sustainable environmental awareness

measurement scale can be used without revision. Thus, the final instrument grid for measuring sustainable environmental awareness remains as

presented in Table 1, while the results of the instrument successfully developed in this study are presented in Table 3.

Table 3. Final sustainable environmental awareness instrument

No.	Statement Item
1	I look for information about environmental issues on social media, YouTube, or online news
2	Environmental issues are the responsibility of the government and large companies, not the responsibility of each individual
3	I am concerned when I see dirty and polluted environmental issues at school or at home
4	I always discuss environmental issues with friends and family
5	Saving water and electricity is not a priority for me because the bills are still affordable
6	I am concerned when I see many people using private vehicles, which causes air pollution
7	I don't need to take action to reduce my carbon footprint in my daily life because it doesn't have a significant impact
8	I regret the pollution of rivers due to the disposal of garbage and waste
9	I appreciate the importance of preserving animal and plant diversity
10	I am uncomfortable with the smoke produced by vehicles or the burning of garbage around my neighborhood
11	I don't need to learn about environmentally friendly actions because my current lifestyle is comfortable for me
12	I sort organic and inorganic waste at school and at home
13	I try to make compost from food scraps
14	I bring my own shopping bags to avoid using disposable plastic bags
15	I do not feel guilty when I litter
16	I turn off electronic devices when they are not in use
17	I conserve water in my daily life
18	I share my knowledge about the importance of protecting the environment with others
19	I actively participate in environmental conservation activities
20	I don't have to worry about sorting my trash because it will end up in a landfill anyway
21	I feel responsible for protecting the environment for future generations

Therefore, the next process is that the instrument will undergo field testing on samples that meet the criteria previously determined through empirical validity testing.

An empirical validity test was conducted for field testing of the developed instrument on a predetermined sample. This validity test was conducted in a 12th-grade high school class with 70 students majoring in mathematics and natural sciences. The sample met the minimum ratio of 3:1 between the number of samples and the number of items in the instrument. This ratio was considered adequate for conducting item validity testing using Pearson's product-moment correlation. Empirical validity testing analysis

was performed by calculating Pearson's product-moment and comparing the calculated r value with r table value. The empirical validity test results obtained, if the calculated r value is $\geq r$ table value and has a positive value, then the item/statement is declared valid (Ghozali, 2019). The empirical validity test results show a difference in the strength of the relationship between the item score and the total score. The r table value is determined based on the sample size and the significance level used, namely 70 people. Therefore, the r table value used is 0.235. Table 4 below presents the calculated r value for each statement item in the sustainable environmental awareness scale.

Table 4. Empirical validation

Item Number	Calculated r Value
X1	0.308
X2	0.245

Item Number	Calculated r Value
X3	0.401
X4	0.521
X5	0.526
X6	0.387
X7	0.455
X8	0.344
X9	0.622
X10	0.313
X11	0.507
X12	0.545
X13	0.580
X14	0.516
X15	0.405
X16	0.586
X17	0.617
X18	0.526
X19	0.539
X20	0.512
X21	0.637

Based on Table 4, all 21 items (N = 21) in the sustainable environmental awareness scale had a calculated *r* value greater than or equal to 0.235 and were positive. Therefore, all items were declared valid. In addition, the calculated *r* values provide information regarding the strength of the correlation between each item and the total score. The correlation value can also be expressed as a percentage by observing the product-moment values. Therefore, the 21 statement items that have been developed are

capable of measuring the level of sustainable environmental awareness. The higher the correlation value (approaching 100%), the more accurately the item measures the level of sustainable environmental awareness.

The analysis continued using exploratory factor analysis (EFA) to group the instrument items into factors representing the measured constructs. The results of the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test analyses are presented in Table 5.

Table 5. EFA analysis results

Parameters	Value
KMO	0.723
Bartlett's Test	<0.001

KMO value of 0.723 indicates that the data has a sufficient sample size. KMO value above the minimum threshold of 0.50 indicates that the proportion of variance between items that can be explained by latent factors is quite large and the partial correlation between items is relatively small. The Bartlett's Test significance value <0.001 indicates that the inter-item correlation matrix is significant. This means that there is a significant correlation between the items of the instrument, so that each item does not stand independently.

Reliability testing assessed the consistency of measurement results and determines whether there are errors in the measurement. Measurement errors may result in inconsistencies

when repeated measurements are conducted on the same sample. Meanwhile, measurement reliability is related to errors in sample measurements, which refer to inconsistencies in measurement results when repeated measurements are performed on different samples (Ramadhan et al., 2024). An instrument is considered reliable if the Cronbach's alpha value exceeds 0.60 (Taherdoost, 2016). Based on the reliability test results, the Cronbach's alpha value obtained was 0.823 for the 21 items of the sustainable environmental awareness scale that had previously been declared valid. Based on the interpretation criteria in Table 2, a Cronbach's alpha value of 0.823 indicates very high reliability. Therefore, this instrument

demonstrates adequate internal consistency to be used in research.

CONCLUSION

The results of the study show that: (1) The instrument developed to measure sustainable environmental awareness in chemistry learning consists of three categories: sustainable practice awareness, behavioral and attitudinal awareness, and emotional awareness. (2) Based on theoretical validity testing, expert judgment assessed that the instrument was deemed suitable for use without revision, while empirical validity testing showed that all 21 statement items were declared valid. In addition, based on the reliability test of the 21 valid items, the sustainable environmental awareness scale instrument was declared reliable with a Cronbach's alpha value of 0.823, indicating very high reliability. The EFA results also confirmed that there is a correlation between items in the developed instrument statements. It is expected that this research can serve as a handy reference to conduct studies on the level of sustainable environmental awareness in the future.

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