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Development of a Sustainability Awareness Tool for High School Biology Students

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Abstract

In the context of classroom-based learning, the majority of students tend to acquire cognitive knowledge. It is essential for students to not only acquire cognitive knowledge but also develop awareness of sustainability as a result of teaching and learning activities. The purpose of this study was to develop an instrument to measure sustainability awareness among high school students. Developing an instrument of sustainability awareness for students is important to measure and encourage their understanding and actions in preserving the environment sustainably. The instrument developed consists of three subdimensions: economy, society, and environment. This instrument assesses awareness of the concept of sustainable development and practices, attitudes, and moral values for sustainability at the individual level. This study used the Rasch modeling analysis technique. The instrument is a closed questionnaire containing 21 items using a 4-point Likert scale. The results of the Rasch modeling showed that the overall Cronbach's alpha reliability coefficient was in the "good" category, while the item reliability coefficient was in the "very good" category. However, the student reliability coefficient was in the "weak" category. The results of the instrument validity test showed four invalid items. These items showed ZSTD and Pt Mean Corr values that did not meet the established criteria. However, the existence of invalid instrument items and weak student reliability coefficients did not affect the overall quality of the instrument. Therefore, it can be concluded that the developed instrument is considered appropriate for measuring the sustainability awareness profile of students.

Keywords: Biology; high school; sustainability awareness

INTRODUCTION

The concept of sustainable development was first formally discussed in the Brundtland Report, published by the World Commission on Environment and Development in 1987. The corresponding rapporteur defined it as "sustainable development that meets the needs of the present generation without compromising the ability of future generations to meet their needs" (Riak & Bill, 2022). Education has the potential to instill in individuals the intrinsic motivation to engage in pro-environmental behaviors (Akhir *et al.*, 2022; Yonanda *et al.*, 2023). This intrinsic motivation gives rise to an environmentally conscious disposition and character, which in turn informs decision-making and action with a view to safeguarding and sustaining the natural environment. Education is a fundamental means of achieving sustainable development, as it cultivates the knowledge, skills and attitudes required to make informed decisions and take action that safeguards the natural environment (Sheasby & Smith, 2023). The classroom is an optimal setting for teachers to promote and instill

values and attitudinal changes that facilitate the achievement of sustainable development goals. It is therefore evident that quality education is a fundamental requirement for the achievement, expansion and effective implementation of sustainable development goals (Velázquez & Rivas, 2020).

Education for Sustainable Development (ESD) is a pedagogical approach that is based on the fundamental principles of sustainability at all levels of learning and across a range of disciplines (UNESCO, 2009). The inculcation of values, ethics, and morals is an integral aspect of the educational process. Consequently, education occupies a pivotal role in shaping our cognitive and behavioral patterns in a manner that fosters a sustainable future(Hofman-Bergholm, 2018). In its 2017 report, UNESCO identifies sustainability competencies as a central component of the knowledge, capacities, skills, motives, and affective dispositions that individuals require to engage effectively in diverse and complex contexts. These competencies pertain to abilities in systems thinking, anticipatory thinking, understanding norms and values, strategic thinking, collaboration, critical thinking, self-awareness, and integrated problem solving (Tomas *et al.,* 2020). ESD can be classified into two categories: cognitive abilities and affective abilities. The former encompasses inquiry and research, lateral thinking, analytical and creative thinking, collaboration, communication, literacy, and observation of ESD implemented in structured programs that have a positive impact on sustainability practices (Mahat *et al.*, 2020).

The term "sustainability awareness" is used to describe the process of fostering an understanding of the core objectives of Education for Sustainable Development (ESD). In order to ascertain the extent to which students have attained the objective of Education for Sustainable Development (ESD), it is necessary to devise an instrument for measuring their sustainability awareness profile. In their 2019 study, Atmaca, A. C., Kıray, S. A., & Pehlivan sought to develop a scale to assess prospective teachers' sustainability awareness. The resulting scale comprises three subdimensions, namely economy, society, and environment, and consists of a total of 36 questionnaire items. In some cases, instruments that focus exclusively on environmental issues may prove insufficient for evaluating ESD projects, which typically encompass environmental, social, and economic dimensions. Accordingly, the concept of Sustainability Awareness (SC) was developed and operationalized into a survey instrument (Sheasby & Smith, 2023). The SC concept encompasses elements of environmental, social, and economic sustainability. The Sustainability Awareness Questionnaire (SCQ) allows for the examination of students' knowledge, attitudes, and behaviors related to sustainability (Korsager & Scheie, 2019). Furthermore, the SCQ encompasses pivotal elements of education, which are vital for gauging comprehensive sustainable development awareness and young people's preparedness for future action on sustainability matters (Olsson *et al.*, 2019).

The concept of sustainability has become a pivotal element of contemporary educational practices, particularly within the context of high school biology. In light of the pressing nature of the global environmental crisis, it is imperative that instruments be developed to measure and enhance sustainability awareness among high school students. Despite the existence of a number of instruments designed to assess sustainability awareness, many of these are not effectively integrated into the context of biology education. The majority of extant instruments are more general in nature and thus less suitable for evaluating the specific aspects of biology education related to sustainability. Previous research indicates that existing sustainability awareness instruments are often less relevant to local curricula and insufficiently comprehensive in measuring students' understanding of more complex sustainability concepts. Furthermore, some of these instruments are insufficient in prompting students to apply their knowledge to real-world contexts pertaining to environmental issues.

Accordingly, this study instrument will not only measure the level of sustainability awareness but also assess the extent to which students can apply sustainability concepts in their daily lives and in the context of biology education. The novelty of this research lies in its more focused and specific approach to measuring sustainability awareness, as well as its closer integration with the biology curriculum taught in high schools. Therefore, the objective of this study is to address these

shortcomings by developing an instrument that is specifically designed for high school biology students.

METHOD

This research employs the R&D (research and development) method. The development model employed in this study is based on the ADDIE model, which comprises the following five stages: analysis, design, development, implementation, and evaluation. These stages are illustrated in Figure 1, which is adapted from the work of Wajdi & Tandililing (2022). In this study, the sampling technique employed was simple random sampling. Simple random sampling is a method of selecting a sample from a population in a random manner, without any consideration of the strata within that population (Soni & Himanshu, 2023). The instrument was developed in the form of a questionnaire comprising 21 questions.

Figure 1. Research procedure using the ADDIE model

The ADDIE model can be employed to develop a sustainability awareness instrument for high school biology students in the following manner: The subsequent stage of the ADDIE model is analysis. It is first necessary to identify the need for the instrument, as well as the characteristics of the students for whom it is intended and the key sustainability concepts. The design phase entails the formulation of a conceptual framework that integrates the identified needs, student characteristics, and key sustainability concepts. A blueprint should be created, measurement methods determined and a prototype designed. The subsequent phase is the development of the instrument. The instrument should be developed, pilot testing conducted, and any necessary revisions made based on the feedback received. The final stage of the process is implementation. The instrument should be administered in actual settings, data collected, and usage instructions provided. The evaluation stage is concerned with the assessment of the instrument's efficacy and the identification of areas for improvement. Formative and summative evaluations should be conducted in order to assess the effectiveness of the instrument and to implement any final refinements.

The data collection process entails the distribution of questionnaires to high school students who have studied or are currently studying biology. The data were obtained from a statistical assessment of the questionnaire items, which had been distributed based on the established validity and reliability values to evaluate the suitability of the instrument developed. Furthermore, the data collection technique employed in this study utilized a questionnaire as the instrument. A questionnaire

is a data collection technique whereby a set of questions or written statements is provided to respondents for completion. The data were collected using Google Forms. The data analysis technique employs Rasch modeling using the WinStep application, with input from expert lecturers. The data were analyzed to assess the suitability of the newly developed instrument in comparison to the previously validated instrument. This was done by evaluating the validity of each item, the reliability of the instrument as a whole, the reliability of each sub-dimension, the performance of students in different groups, and the classification of awareness levels.

RESULT AND DISCUSSION

The findings and discussion in this study are presented in accordance with the stages of the ADDIE model. The model can enhance efficiency, effectiveness, and user experience across a range of fields, guaranteeing that the final product aligns with the desired objectives and quality benchmarks (Nurfitri *et al*, 2022; Pramono, 2022; Puspitasari *et al.*, 2023). The following ADDIE stages were conducted as part of this study: The first stage is analysis Stage. In this phase, the fundamental competencies and core competencies of the biological sciences, along with the relevant literature, are identified and analyzed in order to develop the appropriate assessment instruments. The analysis stage is fundamental in various fields, allowing researchers to develop deeper into complex processes, increase efficiency, and encourage innovation (Siregar, 2023). The results of the interview indicated the absence of an instrument for measuring student sustainability. Concurrently, students demonstrated a limited understanding of sustainability issues, and a discrepancy was observed between their cognitive knowledge and their actual comprehension.

The second stage is design stage. In this phase, the instruments are designed in accordance with the analyzed material and supporting journals. Subsequently, a limited trial was conducted with lecturers and biology teachers, and a readability trial was conducted with students. Trials are of great importance not only in the design phase but throughout the research process, as they facilitate the production of reliable and applicable results (Saripudin *et al.*, 2020). Following the analysis stage in the field, the design of the sustainable awareness instrument is then carried out. A total of 21 instrument items are based on the awareness category and ESD sub-dimensions. The following is a presentation of the proposed instrument in tabular form (see Table 1).

Table 1. Instrument propositions based on awareness categories and sub-dimensions

Sustainability aspects	Sustainability awareness	Questionnaire question number
Environmental aspects	Awareness of sustainable practices	3,6,8
	Behavioural and attitudinal awareness	1, 9,
	Emotional awareness	4, 17
Social aspects	Sustainable practice awareness	10, 14, 20
	Behavioural and attitudinal awareness	2, 19
	Emotional awareness	16, 18,
Economic aspects	Sustained practice awareness	7, 11, 13,
	Behavioural and attitudinal awareness	12, 21
	Emotional awareness	5, 15

Then the third stage is development stage. In this phase, the objective is to develop instruments that will facilitate enhancements to the existing test. This stage is dedicated to the refinement and enhancement of the designed instrument, with the objective of ensuring its efficacy and validity. This is a crucial aspect for the improvement of the test (Rahmawati *et al.*, 2024). The next stage is implementation stage. The developed instruments were subjected to extensive testing with large groups. The instrument has been subjected to extensive trial through the Google Form platform. Large-scale group assessments frequently necessitate the deployment of a range of bespoke

instruments to assess disparate skills and abilities across heterogeneous populations (Yang & Lee, 2021). The instrument was disseminated to six educational institutions in Bogor City and Bogor District. The instruments were distributed to two classes of grade 11 science majors in each school. The data that should have been collected from approximately 350 respondents was, however, only obtained from 250 respondents.

The last stage is evaluation stage. The evaluation stage entails the analysis of the results obtained from the broad trial. The following section presents a description of the quality analysis of the instruments that have been developed. The validity of the scale in the questionnaire was evaluated using the Rasch modelling Winstep application. Winsteps has been employed to analyse test instruments designed to assess students' abilities in science, offering insights into the suitability of items and the reliability of the assessment (Monigir *et al.*, 2024). Winsteps has been demonstrated to be a valuable tool for Rasch modelling applications, providing detailed insights and reliable calibration across a range of areas (Boone *et al.*, 2014). The table below shows the validity numbers per questionnaire item obtained through this process.

Table 2. Questionnaire validity scale

Question items	Measure validitas
1	-1.28
2	0.78
3	1.23
4	-0.71
5	-0.15
6	-0.91
7	-1.19
8	-0.19
9	0.06
10	-0.21
11	-0.81
12	0.91
13	0.91
14	0.93
15	-0.26
16	-0.06
17	0.1
18	0.74
19	-0.32
20	0.05
21	0.4

A total of four items out of the 21 included in the study were identified as invalid. The items identified as invalid are item numbers 3, 14, 12 and 17, as the ZSTD and Pt Mean Corr values do not satisfy the requisite criteria. Invalid items are not employed in the measurement of the sustainability awareness profile. In the development of measurement tools to assess sustainability awareness profiles, the process of discarding invalid items is undertaken to ensure the validity and reliability of the instrument (Mahat *et al.*, 2019; Villamor *et al.*, 2023). The importance of item validation through rigorous analyses, such as confirmatory factor analysis, reliability tests, and content validity assessments, is emphasised in studies focusing on sustainable event awareness, sustainable development goal knowledge, and earth thermal performance awareness. By removing items that do not meet the requisite standards, researchers can ensure that the final scale accurately measures the targeted features within the sustainability awareness domain. This meticulous approach guarantees that the developed instrument is robust, reliable, and able to effectively evaluate individuals' understanding and awareness of sustainability concepts (Amelia *et al.*, 2020).

Table 3. Reliability coefficient and cronbach alpha of each sub-dimension

Dimention	Reliability Coefficient	Cronbach alpha Coefficient
Environmental sub-dimensions	0.99	0.50
Social Sub-dimension	0.97	0.37
Economic Sub-dimensions	0.99	0.49
Overall average	0.98	0.45

The instrument is deemed to be reliable overall, falling within the 'good' category. This indicates that it can be used to measure the sustainability awareness profilem. The overall reliability of an instrument is crucial for accurately measuring Sustainability Awareness profiles. Research conducted in Indonesia and Turkey developed measurement tools to assess sustainability awareness in educational and sports settings (Velázquez & Rivas, 2020; Muthia *et al.*, 2021). The studies utilized various methods, such as surveys and Rasch modeling analysis, to ensure the reliability and validity of the instruments. Results showed that the instruments had good overall reliability, indicating that they can effectively measure sustainability awareness levels across different dimensions like environmental, social, economic, and event-related aspects. This reliability allows for the instruments to be utilized in assessing and enhancing sustainability awareness among students, athletes, and individuals involved in sports activities, demonstrating the practical applicability of these tools in promoting sustainable development initiatives (Torres & Rivera, 2022). Nevertheless, the reliability coefficient includes invalid instrument items in the "good" category, thereby ensuring that the instrument's quality remains unaffected. Consequently, the instrument developed is suitable for measuring the profile of sustainability awareness in students. Invalid instrument items can still fall within the reliability coefficient in the good category, as highlighted in the research papers. While validity is crucial for ensuring that an instrument accurately measures what it is intended to measure (Fatayah *et al.*, 2022; Ramadhan *et al.*, 2024), reliability focuses on the consistency and stability of the instrument's measurements. Even if certain items are deemed invalid due to various tests like Corrected Item to Total Correlation or content validity analysis, they may still contribute to a reliable overall instrument if they consistently produce similar results when tested (Sudaryono *et al.*, 2019). However, it is essential to address invalid items to enhance the overall quality of the instrument and ensure that it effectively measures the intended constructs, as validity and reliability are both crucial aspects of instrument development and assessment in research.

The development of instruments to assess awareness and sub-dimensions of Education for Sustainable Development (ESD) is a crucial step towards the implementation of effective teaching and learning practices (Lestari *et al.*, 2022). It will strengthen the learning process when exploring nature like ocean ecosystem or even in laboratory (Pertiwi & Saputri, 2020; Fatonah *et al.*, 2023; *Mufida et al.*, 2023). By developing assessment tools and resources that target sustainability awareness and its sub-dimensions, educators can enhance the impact of ESD on students' mindsets and lifestyles, thereby contributing to a more sustainable future.

CONCLUSION

The findings of the research study allow us to draw the following conclusions: A total of four items from the 21-item instrument were identified as invalid. The results of the study indicate that the items in question are not employed as a means of measuring the sustainability awareness profile. 2) The overall reliability of the instrument is deemed to be satisfactory, indicating that it is suitable for measuring the sustainability awareness profile.In light of the aforementioned findings, it can be posited that the instrument developed is, on the whole, consistent across all items. However, the level of difficulty may not be optimal, given that student responses exhibit a higher level of ability than would be expected. This is likely due to the higher validity of the student distribution compared to that

of the item distribution. Conversely, students exhibiting above-average awareness are found to be in the frequent category. Moreover, the reliability coefficients for the ESD aspects are high and reliable. This research is beneficial for the nation, especially teachers, because it can improve teachers' knowledge in measuring the level of sustainability awareness and assessing the extent to which students can apply the concept of sustainability in everyday life and in the context of biology education.

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