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Identification of Sustainable Environmental Literacy Needs as A Basis for Developing SDGs-Based Instruments

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Abstract

Sustainable environmental literacy is an important competency in supporting the achievement of the Sustainable Development Goals (SDGs), especially for prospective science teacher students. This study aims to identify the need for sustainable environmental literacy as a basis for developing measurement instruments that are relevant to the context of education and global environmental challenges. This study uses a descriptive approach by compiling indicators based on cognitive, affective, and psychomotor dimensions, and considering aspects of social awareness and real action. The results of the analysis show a gap between students' pro-environmental knowledge and attitudes and their actual behavior in everyday life. This finding emphasizes the importance of instruments that are able to describe environmental literacy conditions holistically to support transformative education and form agents of change who care about environmental sustainability.

How to Cite

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INTRODUCTION

Environmental issues have emerged as global concerns due to escalating ecosystem degradation and climate change that threaten the sustainability of life on Earth. In response, the Sustainable Development Goals (SDGs) emphasize the importance of collective action, primarily through education, to address these challenges. One key strategy to support the SDGs agenda is through strengthening sustainable environmental literacy, which includes knowledge, awareness, skills, and attitudes needed to act pro-environmentally (Escoz-Roldán et al., 2020; Tharasook et al., 2020; Yadav et al., 2021).

In Indonesia, research on environmental literacy has attempted to understand public awareness and behavior toward environmental issues. Studies show diversity in teaching techniques, methodological approaches, and research designs, indicating an interdisciplinary understanding of environmental literacy (Faizah, 2020; Fakhriyah et al., 2024; Hermawan et al., 2024; Hnatyuk et al., 2024). However, the publication trends are inconsistent, and the research findings are varied, demonstrating the need for more comprehensive and contextual approaches.

Despite efforts, environmental literacy development remains suboptimal. Hermawan et al., (2022) found that high school students in Denpasar scored high in knowledge and cognitive skills but only moderate in attitudes and behavior. Although a significant relationship was observed between knowledge and skills, and between attitudes and behavior, there was no correlation between knowledge and attitudes, suggesting that increasing knowledge alone does not guarantee pro-environmental behavior. This gap is reinforced by Liang et al. (2018), who emphasized the disconnection between cognitive dimensions and actual behavior, highlighting the need for a multidimensional approach to environmental literacy measurement. Veisi et al., (2019) also stressed the role of affective components in bridging this gap, while the KAASPA framework introduced evaluative and participatory dimensions, though it remains underutilized in contextual assessments.

The challenges extend to the higher education context, particularly in preparing future teachers. Roshayanti et al. (2020) showed that multi-level strategies curriculum integration, campus initiatives, and institutional commitment that effectively cultivate sustainable values and encourage active student participation. Nonetheless, current teacher education programs still fail to equip prospective teachers with comprehensive environmental literacy. Studies by Marlina & Lathifah (2024), using the ELAMt instrument revealed significant gains in knowledge. However, affective and behavioral domains remain lacking, indicating that existing tools may not fully capture the holistic aspects of sustainable literacy.

Meanwhile, innovations such as developing environmental literacy knowledge models and fuzzy evaluation methods have been explored (Huang & Te Hsin, 2023), but their integration into pre-service teacher education remains limited. Furthermore, curriculum models like zero-waste education for prospective madrasah teachers (Widayanti & Widyawati, 2024) and environmental-based teacher training (Amin & Maritasari, 2023) demonstrate some success in improving knowledge and attitudes, yet behavioral changes have not shown significant progress.

A growing area of concern is insufficient emphasis on low-carbon literacy. Yuliyanto & Rahmawati (2025) found that although prospective teachers recognize importance of reducing CO_2 emissions, they have misunderstandings about energy use and a lack of confidence in applying low-carbon practices. While positive correlations among cognitive, affective, and psychomotor domains exist, weak connection between knowledge and behavior suggests an urgent need improved conceptual understanding and quantitative literacy in evaluating carbon footprints.

Addressing these challenges calls for instrument development that captures the full scope of sustainable environmental literacy. Misbah (2024) and Fatimah et al. (2024) emphasize that sustainability literacy must be integrated into lesson planning through reflective pedagogy and professional training. Pérez-Martín & Esquivel-Martín (2024), confirmed that sustainability-competency-based teacher training has long-term effects on students' attitudes. Similarly, Rieckmann & Barth (2022) argue for a transdisciplinary approach in teacher curricula to promote ecological awareness.

However, current instruments often lack contextual sensitivity and multidimensional constructs. Seo et al. (2023) emphasize the importance of culturally adapted instruments to close the gap between environmental knowledge and action. Szczytko et al. (2019) proposed a validated tool incorporating cognitive, affective, and conative dimensions, while Perez-Rodriguez et al. (2017) examined the use of Likert scales for capturing environmental attitudes. However, these instruments are rarely adapted to local educational practices in Indonesia.

Additionally, Dada et al. (2017) and Yang & Wang (2025) found that emotional involvement and direct experiences in nature are critical

for forming sustainable behaviors, reinforcing the importance of affective components in literacy assessment. Active learning models that connect students with real environmental actions such as recycling, water conservation, and tree planting have strengthened internal motivation and environmental responsibility.

In science education, Gheith (2019) and Handayani & Triyanto (2022) suggest that integrating environmental issues into science curricula enhances students' understanding of the relevance of science to real-world problems, yet many prospective teachers still struggle with critical thinking skills. Walshe & Tait (2019) demonstrated that project-based and self-reflective learning significantly improve the internalization of sustainability values.

Given these findings, prospective science teachers are strategically positioned as future agents of change. Their readiness integrate global environmental challenges such as pollution, climate change, and biodiversity loss into learning designs is essential for promoting SDGs. However, current instruments are often fragmented and fail to assess sustainable environmental literacy comprehensively across cognitive, affective, psychomotor, social, and global awareness domains.

The scientific novelty of this study lies in identifying the urgent need for a comprehensive, contextual, and multidimensional instrument to measure sustainable environmental literacy in prospective science teachers. While numerous studies have assessed environmental literacy, few offer an integrative measurement model that reflects educational realities and sustainable development goals. This research thus marks a foundational step toward designing a theoretical and empirical instrument that aligns with SDGs principles and supports the development of future educators capable of fostering sustainable behaviors in the next generation.

METHOD

The research was conducted at the Faculty of Mathematics and Natural Sciences (FMIPA) Semarang State University and the Faculty of Tarbiyah and Teacher Training UIN Salatiga in the even semester of the 2023/2024 academic year. The subjects of the research were 2nd semester students in Science Education Study Program from two different universities. A total of 140 students were given a closed questionnaire related to sustainable environmental literacy consisting of 20 questions. The compilation and analysis of questionnaire questions that describe twelve indicators of aspects of sustainable environmental literacy. The initial instrument consisted of four main parts: knowledge and understanding, daily habits, attitudes and actions, and socio-global awareness. The questionnaire tested used a dichotomous scale with two categories so that the data obtained was dichotomous data had been tested for validity and reliability. The questions asked were made as positive and negative questions. Sustainable Environmental Literacy indicators as Basis for Developing SDGs-Based Instruments used in research are presented in Table 1.

Table 1. Sustainable Environmental Literacy Indicators

Aspect	Indicators
Knowledge of Environmental Processes and Systems	1. Identifies causes of climate change and environmental degradation
	2. Understands environmental pollution caused by human activities
	3. Understands role renewable energy in environmental sustainability
Environmental awareness and sensitivity	4. Demonstrates environmentally friendly consumption habits
	5. Demonstrates energy and resource-saving behavior
	6. Evaluates environmentally harmful daily transportation habits
Decision-making attitudes toward environmental issues	7. Supports active participation in community environmental programs
	8. Shows concern for environmental health in personal choices
	9. Reflects consideration in everyday personal decisions
Engagement in responsible environmental behavior	10. Supports integration of environmental values into early education
	11. Demonstrates awareness of global environmental issues
	12. Understands the role of individual responsibility in sustainability

This study employed a qualitative descriptive approach, aiming to explore patterns of environmental literacy without statistical hypothesis testing. The data analysis was conducted using descriptive statistics, in which the frequency and percentage of each item response were calculated. These frequencies were then grouped based on the four literacy dimensions, and the results were visualized through graphs and tables to highlight response trends.

The interpretation of data was carried out qualitatively by examining the patterns and discrepancies between students' responses across different dimensions, particularly focusing on identifying gaps between cognitive understanding and behavioral expression. This analysis was intended to provide a holistic picture of the students' sustainable environmental literacy and its implications for curriculum development. To systematically describe the stages carried out in this research, the following research method flow diagram is presented in Figure 1, which shows the steps starting from determining the location and subject, to the data analysis and interpretation process.

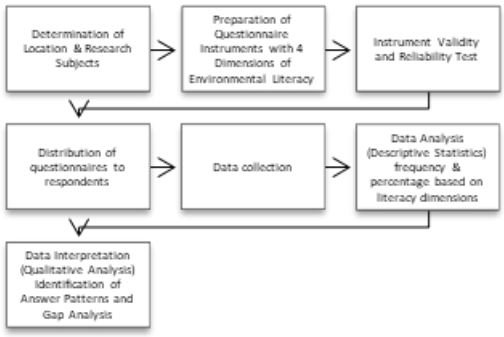

Figure 1. Flowchart of Environmental Literacy Research Stages for Prospective Science Teachers

RESULT AND DISCUSSION

The study used a questionnaire consisting of 20 questions and covering four aspects of sustainable environmental literacy, namely knowledge and understanding, daily habits, attitudes and actions, and social and global awareness. The distribution of questions in the questionnaire based on aspects of sustainable environmental literacy can be seen in Table 2.

The study was conducted by analyzing the need for sustainable environmental literacy in different study programs and universities. However, this study was not limited and did not differentiate the results of the analysis of the two study programs. The study focused on the need for sustainable environmental literacy at tertiary level.

Table 2. Distribution of Statements in the Sustainable Environmental Literacy Questionnaire

Indicator	Questionnaire Statement	Item
1	Climate change is caused by human activities such as the burning of fossil fuels.	1
	I am familiar with the term greenhouse effect.	2
2	I know that plastic-based products are difficult to decompose and pollute the environment.	3
	I understand the importance of water conservation in maintaining the ecosystem.	4
3	I know that renewable energy, such as solar power, can reduce pollution.	5
4	I use eco-friendly products, such as cloth shopping bags, in my daily activities.	6
	I reduce water usage by turning off the tap when not in use.	7
5	I do not separate waste by type (organic and inorganic).	8
	I leave the lights on when I sleep.	9
6	I use private vehicles more often than public transportation.	10
7	I support the greening movement or tree planting in my neighborhood.	11
	I participate in environmental cleaning activities such as mutual cooperation.	12
8	I am not interested in environmental activities or campaigns.	13
	I don't really care whether the products I buy contain chemicals that are harmful to the environment or not.	14
9	I prefer to use tissues rather than bring my own handkerchief.	15
10	I agree that environmental education should be taught at an early age.	16
	I support government policies to reduce carbon emissions.	17
11	I feel it is important to stay up to date with news about the environment and climate change.	18
	I recognize that my everyday actions impact the global environment.	19
12	I believe that individual actions have little impact on environmental sustainability.	20

The results were obtained from a questionnaire that could measure sustainable environmental literacy and were analyzed descriptively. The questions asked in the questionnaire were made as positive and negative questions. The results of the analysis of sustainable environmental literacy are presented in Figure 2.

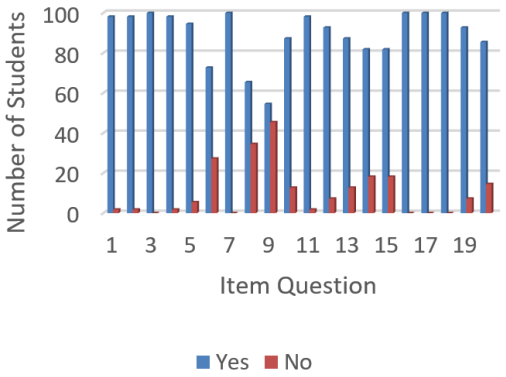

Figure 2. Results of Sustainable Environmental Literacy Needs Analysis

The results of the needs analysis in Figure 2 show that prospective science teacher students generally have a high level of awareness of environmental issues, especially understanding the effects of fossil fuel use (1), the greenhouse effect (2), the importance of water conservation (4) and the use of renewable energy (5). Students are also aware of the dangers of using plastic products that are difficult to decompose and pollute the environment (3). Positive responses were also given regarding the importance of environmental education from an early age (16), government policies that reduce carbon emissions (questions), and greening activities such as planting trees (11). Students are aware that human actions will affect the condition of the earth and support government and organizational efforts to reduce environmental damage.

However, high awareness of these issues has not been achieved, and appropriate actions have not been taken. Many students are aware of the importance of water and energy conservation, but not many have implemented the habit of turning off the water tap when not in use (7) or reducing energy use by turning off the lights when sleeping (9). Students also understand the importance of separating waste based on type (organic and inorganic), but many do not implement this habit (8). Students tend to prefer using tissues rather than carrying their own handkerchiefs (15) and use private vehicles more often than public transportation (10).

Prospective science teacher students possess a high level of environmental literacy regarding various environmental issues, which is not fully reflected in their daily actions. The gap between theoretical understanding and actual practice must be addressed through continuous environmental literacy development integrated into learning, so prospective science teachers understand environmental issues. They can change environmentally conscious behaviors and habits in their daily lives. This finding emphasizes the importance of instruments that can holistically describe environmental literacy to support transformative education and develop agents of change who care about environmental sustainability.

Although prospective science teacher students understand environmental issues, this is not fully reflected in their daily actions. This phenomenon is the environmental attitude-behavior gap, the difference between environmental attitudes or knowledge and actual behavior (Marcinkowski & Reid, 2019). Liobikiene & Poškus (2019) state that environmental knowledge alone cannot drive environmentally conscious behavioral change. This gap is influenced by various interacting internal and external factors. One of the leading causes is the predominantly cognitive approach to environmental education, which fails to address the affective and psychomotor aspects in a balanced way.

Cai et al. (2025) and Zhang & Cao (2025) found that affective dimensions, such as environmental sensitivity and concern, are important mediators in the formation of pro-environmental behavior. Environmental education that focuses too much on cognitive aspects without addressing the affective and conative dimensions risks failing to internalize sustainability values. Leite (2024) also states that environmental education, particularly in climate change, requires a holistic transformation of the curriculum, pedagogy, and assessment system to address students' affective and ethical domains.

Furthermore, a lack of direct experience with nature also contributes to students' weak emotional connection to environmental issues, which results in low motivation to act. Baierl et al. (2022) state that informal experiences and direct interaction with nature can significantly increase emotional engagement and positive attitudes toward the environment. Without these real-world experiences, understanding environmental concepts often becomes abstract and disconnected from the context of everyday life. Therefore, educational interventions that are reflective, project-based, and prioritize direct inter-

action with real-world environments are essential to bridge the gap between knowledge and action.

Direct interaction and experience with the environment are important in shaping pro-environmental attitudes and behaviors (Baierl et al., 2022). External barriers such as limited facilities and unsupportive social norms also prevent students from implementing environmentally conscious behavior. External factors play an important role in environmental behavior (Kirsten & Biyase, 2025). Therefore, it is necessary to develop a holistic environmental literacy evaluation instrument to address the gap. Comprehensive measuring instruments to support effective environmental education are important (Hamidah, 2024; Hastuti et al., 2020).

Comprehensive measuring instruments to support effective environmental education are very important because environmental literacy not only covers aspects of knowledge but also includes attitudes, values, and behaviors that support sustainability. Without holistic measuring instruments, evaluations of the effectiveness of environmental learning will tend to be biased towards the cognitive dimension alone and ignore the affective and conative dimensions, which are more decisive for real behavioral changes.

Good measuring instruments must be able to capture the entire spectrum of sustainability competencies. Instruments that only focus on conceptual understanding are not enough to describe an individual's readiness to become an agent of change in environmental issues. Therefore, the development of valid, reliable, and multidimensional measuring instruments is a strategic step in forming prospective science teacher students who are not only intellectually aware but also moved to act in real ways for environmental sustainability.

Strengthening sustainable environmental literacy through integrative learning is urgently needed. Integration of environmental literacy in science learning has been shown to increase students' awareness and pro-environmental attitudes. Character education based on environmental literacy in science learning can shape students' environmental attitudes (Rismawati et al., 2025). The development of instruments that measure the dimensions of knowledge, concern, ethics, action skills, and reflection is a strategic step to assess and direct student behavior. This effort is expected to form prospective science teachers who not only understand environmental issues but also become role models in real actions that support sustainability.

However, strengthening environmental literacy is not only determined by students' internal factors. However, it is also influenced by various external factors, such as the availability of supporting facilities, school culture, social norms, and family environment. Kirsten and Biyase (2025) emphasized that external obstacles, such as limited facilities and non-conformity with social norms, inhibit students' pro-environmental behavior. Additionally, Baierl et al. (2022) stated that direct interaction with nature and support from the surrounding environment can trigger changes in attitudes and strengthen students' emotional involvement in environmental issues. Therefore, strengthening environmental literacy must be holistic, involving a supportive learning environment and collaboration between schools, families, and communities.

The development of instruments that measure the dimensions of knowledge, concern, ethics, action skills, and reflection is a strategic step to assess and direct student behavior. This effort is expected to form prospective science teachers who not only understand environmental issues but also become role models in real actions that support sustainability. This is important because teachers have a central role in shaping students' mindsets and habits towards the environment. Through integrative learning and assessments that reflect cognitive, affective, and conative aspects, prospective teacher students can be directed to internalize sustainability values in everyday life.

Comprehensive instruments also help educators identify areas that still need strengthening so that the learning process can be designed in a more targeted manner. Thus, sustainable environmental literacy is not only a conceptual discourse but actually encourages real behavioral changes that have a positive impact on the environment and society. The development of instruments that measure the dimensions of knowledge, concern, ethics, action skills, and reflection is a strategic step to assess and direct student behavior. This effort is expected to form prospective science teachers who not only understand environmental issues but also become role models in real actions that support sustainability.

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Strengthening sustainable environmental literacy through instruments that cover dimensions of knowledge to reflection has a strategic contribution to supporting the Sustainable Development Goals (SDGs), especially SDG 13 (Addressing Climate Change) and SDG 15 (Protecting Terrestrial Ecosystems). Students, as prospective educators, are expected not only to understand scientific concepts related to climate change and biodiversity but also to be able to translate them into actions that encourage conservation and mitigation. Research by Husamah et al., 2022 shows that the integration of environmental literacy in real project-based science learning, such as citizen science, can increase students' awareness and involvement in environmental issues that are in line with the SDGs targets.

Instruments that comprehensively measure literacy dimensions function as tools in mapping individual contributions to achieving the SDGs, especially in the context of education and community involvement (Sandoval-Hernández & Carrasco, 2020). Furthermore, reflection skills measured through sustainable environmental literacy instruments are essential to support ethical and environmentally responsible decision-making, which is in line with the principles of the SDGs. The ability to reflect on personal actions and values in the context of sustainability allows students to build critical awareness of the ecological consequences of their life choices.

According to Szczytko et al. (2019), learning that emphasizes transformation and self-reflection is key to shaping future educators who are oriented toward sustainability. In the context of teacher education, this is an important foundation for shaping the character of educators who are not only academically competent but also committed to the values of sustainability. Therefore, the development of instruments that are aligned with the goals of SDG 4 (Quality Education) is an integral part of the transformative education strategy to support the achievement of the SDGs widely.

Although the results of this study provide important insights into the conditions and needs of sustainable environmental literacy among prospective science teachers, these findings cannot yet be directly translated into operational learning designs or science teacher education curricula. This is because the approach used is still descriptive and exploratory, focusing on identifying needs through questionnaires, rather than on developing or evaluating specific learning interventions. Furthermore, this study does not detail the learning strategies, pedagogical approaches, or mapping of learning outcomes that can be integrated into the curriculum structure. The lack of analysis of the relationship between the findings and existing courses or modules in science education study programs also hinders the direct application of the study findings to the curriculum.

Nevertheless, the findings of this study provide a strong and relevant foundation for developing a more transformative and contextual curriculum. The identification of gaps between knowledge and action, as well as the importance of strengthening the affective and conative dimensions, provide critical reflections for developing a curriculum that emphasizes not only cognitive aspects but also encourages the formation of sustainable values, attitudes, and behaviors in prospective teachers. These results also emphasize the need to integrate environmental literacy into project-based learning, direct experiences with nature, and assessments that reflect sustainability competencies. Thus, although not yet directly applicable, this research contributes as a significant initial step in formulating SDGs-based science teacher education curriculum policies.

This study used a qualitative descriptive approach with a dichotomous questionnaire instrument to identify the need for sustainable environmental literacy in prospective science teacher students from two universities. Although this instrument successfully showed the gap between environmental knowledge and behavior, several limitations must be noted. First, this study did not differentiate the analysis results based on institutions, demographic factors such as gender, socioeconomic background, or previous experience related to environmental education. Second, using dichotomous items limited the depth of participant responses, thus possibly simplifying complex attitudes and behaviors related to environmental literacy. Third, the data were obtained from self-reports, which may contain social desirability bias and do not fully reflect the actual practices of participants in everyday life. In addition, this study has not integrated longitudinal tracking, so it cannot provide a picture of the development of environmental literacy over time or the results of specific educational interventions.

Future research is recommended to use richer, multidimensional instruments, such as Likert scales, performance-based assessments, or

hybrid approaches that combine qualitative interviews and observations. These approaches can capture more in-depth and meaningful data on dimensions of environmental literacy, including reflective ability and ethical reasoning. Comparative studies across institutions, study programs, or cultural settings are also important to identify specific educational needs and contextualized learning strategies. Future research should explore the integration of direct environmental engagement, such as project-based learning, to strengthen the link between environmental awareness and concrete actions among prospective science teachers.

Although the results of this study provide a general overview of the need for sustainable environmental literacy among prospective science teachers, it is important to note that the data analysis was conducted as a whole without differentiating between the respondents' study programs or institutions of origin. This impacts contextual validity because each educational institution has different curriculum characteristics, academic cultures, and learning approaches in integrating environmental issues. Without this differentiation, the findings are generalized and unable to specifically capture the environmental literacy needs of a particular institutional context. Furthermore, the lack of diversity in the analysis also makes it difficult to develop applicable and relevant recommendations for developing locally based policies or curricula. External factors such as students' social and geographic backgrounds or experiences may also influence the gap between knowledge and pro-environmental behavior. However, these are not fully reflected in this study. Therefore, further research is recommended to conduct comparative analyses across institutions or study programs to gain a deeper and more contextual understanding of the dynamics of sustainable environmental literacy in higher education.

CONCLUSION

Prospective science teachers have a high level of understanding and awareness of environmental issues, but this has not been fully reflected in their real behavior. This gap between knowledge and action indicates the need for a sustainable environmental literacy instrument that is able to holistically measure cognitive, affective, and psychomotor aspects, as well as social awareness. The instrument developed is expected to be relevant to the educational context and in line with the principles of the SDGs so that it can be used to support transformative learning and form prospective educators who are oriented towards environmental sustainability.

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REFERENCES

Amin, M. S., & Maritasari, D. B. (2023). Analysis of Environmental Literacy Readiness of Pre-service and Science Teachers in Facing Ecological and Sustainability Challenges. *Jurnal Penelitian Pendidikan IPA*, 9(SpecialIssue), 576–584.

Baierl, T. M., Johnson, B., & Bogner, F. X. (2022). Informal Earth Education: Significant Shifts for Environmental Attitude and Knowledge. *Frontiers in Psychology*, 13(May), 1–8. https://doi.org/10.3389/fpsyg.2022.819899

Cai, Q., Chen, W., Wang, M., & Di, K. (2025). The impact of self-determined efficacy on university student's environmental conservation intentions: an SEM-ANN exploration. *Environment, Development and Sustainability*, 1–38.

Dada, D. O., Eames, C., & Calder, N. (2017). Impact of environmental education on beginning preservice teachers' environmental literacy. *Australian Journal of Environmental Education*, 33(3), 201–222.

Escoz-Roldán, A., Gutiérrez-Pérez, J., & Meira-Cartea, P. Á. (2020). Water and climate change, two key objectives in the agenda 2030: Assessment of climate literacy levels and social representations in academics from three climate contexts. *Water (Switzerland)*, 12(1), 1–33. https://doi.org/10.3390/w12010092

Faizah, U. (2020). Etika Lingkungan Dan Aplikasinya Dalam Pendidikan Menurut Perspektif Aksiologi. *Jurnal Filsafat Indonesia*, 3(1), 14–22. https://doi.org/10.23887/jfi.v3i1.22446

Fakhriyah, F., Masfuah, S., & Margunayasa, I. G. (2024). A Review of Environmental Literacy Learning for Prospective Teachers. *Jurnal Penelitian Pendidikan IPA*, 10(8), 536–547. https://doi.org/10.29303/jppipa.v10i8.8327

Fatimah, S., Rahayuningsih, M., & Marianti, A. (2024). Sustainable Literacy of Climate Change: A Survey Study on Pre-Service Elementary Teachers'. *International Journal of Basic Educational Research*, 1(2), 1–10.

Gheith, E. M. (2019). Environmental literacy among prospective classroom teachers in Jordan. *Inter-*

national Journal of Learning, Teaching and Educational Research, 18(12), 258–279.

Hamidah, N. (2024). Assessing Sustainability Literacy in Green School through Citizen Science Project on Biodiversity Learning Assessing Sustainability Literacy in Green Schools through Citizen Science Project on Biodiversity Learning. *Jurnal Inovasi Pendidikan IPA*. 10(2), 150–159.

Handayani, R. D., & Triyanto. (2022). Seventh-grade students' conceptions of climate change, global warming, and the greenhouse effect. *Journal of Geoscience Education*, 70(4), 490–500.

Hastuti, P. W., Setianingsih, W., & Anjarsari, P. (2020). How to develop students' scientific literacy through integration of local wisdom in Yogyakarta on science learning? *Journal of Physics: Conference Series*, 1440(1). https://doi.org/10.1088/1742-6596/1440/1/012108

Hermawan, I. M. S., Diarta, I. M., & Putu Ayu Paramita Dharmayanti. (2024). Profile, challenge, and opportunity of environmental literacy research in Indonesia: A systematic literature review. *JPBI (Jurnal Pendidikan Biologi Indonesia),* 10(2), 652–665. https://doi.org/10.22219/jpbi.v10i2.33953

Hermawan, I. M. S., Suwono, H., Paraniti, A. A. I., & Wimuttipanya, J. (2022). Student's environmental literacy: An educational program reflections for sustainable environment. *JPBI (Jurnal Pendidikan Biologi Indonesia),* 8(1), 1–9. https://doi.org/10.22219/jpbi.v8i1.16889

Hnatyuk, V., Pshenychna, N., Kara, S., Kolodii, V., & Yaroshchuk, L. (2024). Education's role in fostering environmental awareness and advancing sustainable development within a holistic framework. *Multidisciplinary Reviews,* 7(Special Issue). https://doi.org/10.31893/multirev.2024spe012

Huang, H., & Te Hsin, C. (2023). Environmental Literacy Education and Sustainable Development in Schools Based on Teaching Effectiveness. *International Journal of Sustainable Development & Planning,* 18(5).

Husamah, H., Suwono, H., Nur, H., & Dharmawan, A. (2022). The development and validation of environmental literacy instrument based on spirituality for prospective science teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(12). https://doi.org/10.29333/EJMSTE/12732

Kirsten, F., & Biyase, M. (2025). The Environmental Concern-Behavior Gap in South Africa: An Income-Based Analysis. *Environment and Behavior*, 00139165251318098.

Leite, S. (2024). Towards a transformative climate change education: questions and pedagogies. *Environmental Education Research*, 30(12), 2376–2393. https://doi.org/10.1080/13504622.2024.2365983

Liang, S. W., Fang, W. T., Yeh, S. C., Liu, S. Y., Tsai, H. M., Chou, J. Y., & Ng, E. (2018). A nationwide survey evaluating the environmental literacy of undergraduate students in Taiwan. *Sustainability (Switzerland)*, 10(6), 1–21. https://doi.org/10.3390/su10061730

Liobikiene, G., & Poškus, M. S. (2019). The importance of environmental knowledge for private and public sphere pro-environmental behavior: Modifying the Value-Belief-Norm theory. *Sustainability (Switzerland)*, 11(12). https://doi.org/10.3390/su11123324

Marcinkowski, T., & Reid, A. (2019). Reviews of research on the attitude–behavior relationship and their implications for future environmental education research. *In Environmental Education Research* (Vol. 25, Issue 4, pp. 459–471). Taylor & Francis.

Marlina, R., & Lathifah, S. S. (2024). Does the Current Generation have Adequate Environmental Literacy? Case Study of Prospective Biology Teacher. *Journal of Education Research and Evaluation*, 8(4), 682–692.

Misbah, H. (2024). Integrating Environmental Education into English Speaking Lesson Plan Designed by ELT Pre-Service Teachers in State Islamic University of Lampung, Indonesia. *International Journal on Advanced Science, Education, and Religion*, 7(2), 237–242.

Pérez-Martín, J. M., & Esquivel-Martín, T. (2024). New insights for teaching the one health approach: Transformative environmental education for sustainability. *Sustainability*, 16(18), 7967.

Perez-Rodriguez, U., Varela-Losada, M., Álvarez-Lires, F.-J., & Vega-Marcote, P. (2017). Attitudes of preservice teachers: Design and validation of an attitude scale toward environmental education. *Journal of Cleaner Production*, 164, 634–641.

Rieckmann, M., & Barth, M. (2022). Educators' competence frameworks in education for sustainable development. *In Competences in education for sustainable development: Critical perspectives* (pp. 19–26). Springer.

Rismawati, N., Suprapto, P. K., Sumantri, A., Hernawati, D., & Badriah, L. (2025). Potret Awal Kecerdasan Spiritual Dan Literasi Lingkungan Peserta Didik (Studi Kasus Di SMPN 1 Bojongasih) (Early Portrait of Spiritual Intelligence and Environmental Literacy (Case Study at SMPN 1 Rismawati , *dkk – Potret Awal Kecerdasan Spiritual Dan*. 11, 34–45.

Roshayanti, F., Wicaksono, A. G. C., Minarti, I. B., & Nurkolis. (2020). Integrated learning for improving environmental literacy in high schools. *Journal of Physics: Conference Series*, 1521(4). https://doi.org/10.1088/1742-6596/1521/4/042020

Sandoval-Hernández, A., & Carrasco, D. (2020). A measurement strategy SDG thematic indicators 4.7. 4 and 4.7. 5 using international large scale assessments in education. *Measuring Sustainable Development Knowledge and Skills: Are There yet?: Methodological Progress on SDG Target* 4.7.

Seo, M., Lee, Y., Bae, K., & Son, Y.-A. (2023). Exploring Directions for Uzbekistan Pre-service Science Teacher Education on the Ecological Environment: Based on a Comparison with the Republic of Korea. *Asia-Pacific Science Education*, 9(2), 332–364.

Szczytko, R., Stevenson, K., Peterson, M. N., Nietfeld, J., & Strnad, R. L. (2019). Development and validation of the environmental literacy instrument for adolescents. *Environmental Education Research*, 25(2), 193–210. https://doi.org/10.1080/13504622.2018.1487035

Tharasook, K., Rawang, W., & Srijuntrapun, P. (2020). Environmental Literacy Indicators: Development for Communities in the Ranong UNESCO Biosphere Reserve. *GMSARN International Journal*, 14(4), 212–219.

Veisi, H., Lacy, M., Mafakheri, S., & Razaghi, F. (2019). Assessing environmental literacy of university students: A case study of Shahid Beheshti University in Iran. *Applied Environmental Education and Communication,* 18(1), 25–42. https://doi.org/10.1080/1533015X.2018.1431163

Walshe, N., & Tait, V. (2019). Making connections: a conference approach to developing transformative environmental and sustainability education within initial teacher education. *Environmental Education Research*, 25(12), 1731–1750.

Widayanti, E. Y., & Widyawati, W. (2024). Sustainable Development in Islamic Education: Embedding a Zero-Waste-Based Learning Program for Pre-Service Madrasah Teachers. *Jurnal Kependidikan Dan Kemasyarakatan*, 22(2), 283–296.

Yadav, S. K., Banerjee, A., Jhariya, M. K., Meena, R. S., Raj, A., Khan, N., Kumar, S., & Sheoran, S. (2021). Environmental education for sustainable development. *Natural Resources Conservation and Advances for Sustainability,* 415–431. https://doi.org/10.1016/B978-0-12-822976-7.00010-7

Yang, X., & Wang, Y. (2025). The relation between teaching self-efficacy and behavior of experimental design teaching in Chinese science teachers. *Research in Science & Technological Education*, 43(1), 125–144.

Yuliyanto, E., & Rahmawati, A. (2025). *Pre-service teachers perceptions on low carbon literacy in Indonesian University.*

Zhang, J., & Cao, A. (2025). The Psychological Mechanisms of Education for Sustainable Development: Environmental Attitudes, Self-Efficacy, and Social Norms as Mediators of Pro-Environmental Behavior Among University Students. *Sustainability*, 17(3), 933.