Bibliometric analysis: research trends of environmental literacy in higher education from 2019 to 2023

Muhammad Arif[1,2,*]

[1]Doctoral Program in Geography Education, Faculty of Social Sciences Education, Universitas Pendidikan Indonesia, Jawa Barat, Indonesia
[2]Geography Education Study Program, STKIP Pesisir Selatan, Sumatera Barat, Indonesia

Abstract. Environmental literacy needs to be provided to prospective teacher students. The ability to environmental literacy will help future teachers manage environmentally-based learning. The purpose of this research is to describe the forms of environmental literacy teaching and the instruments used to assess the environmental literacy of prospective teacher students. This research is a bibliometric study. A total of 85 pieces of literature were found in the search using the Publish or Perish (PoP) application from 2019 to 2023, and after a literature analysis process, 22 articles were deemed relevant to answer the research questions. The results of this research show that the forms of environmental literacy improvement courses used in higher education are: 1) providing materials followed by real environmental problem-solving projects, 2) providing materials followed by pedagogic projects, 3) project-based learning using microcontroller technology, 4) STEM-oriented learning, and 5) inquiry-based learning. The instruments used include multiple-choice tests, interviews, and questionnaires. Environmental literacy improvement-oriented learning is widely applied to students majoring in elementary education, science education, and biology education.

1 Introduction

Environmental literacy is defined as an individual's knowledge of the environment and their ability to solve environmental problems [1]. Environmental literacy encompasses an individual's knowledge, skills, and dispositions that support the sustainability of natural and cultural systems [2]. Environmental literacy serves as an effective means to address environmental issues and is a central goal of environmental education [3] .Therefore, environmental literacy can be understood as the knowledge and sensitivity possessed by an individual that is internalized to address environmental issues and promote sustainability.

Environmental literacy comprises four components: knowledge, attitudes, skills, and responsible environmental behavior. The knowledge aspect is related to the physical and ecological systems, while the attitude aspect is associated with sensitivity and self-efficacy

* Corresponding author: muhammadarif@upi.edu

[4]. Environmental literacy encompasses the aspects of knowledge, attitudes, and skills [5,6]. This competence consists of seven elements: affective (related to attitudes and morals), ecological knowledge, social-political knowledge, knowledge of environmental issues, skills (related to actions, systemic thinking, and predictive abilities), responsibility for the environment, and behavior (participation in addressing problems and resolving issues) [7,8].

Environmental literacy can be assessed from cognitive, affective, and psychomotor perspectives, so the assessment of environmental literacy can vary depending on its goals. Various studies have shown variations in the development of environmental literacy assessment tools based on the aspects being evaluated. This information is essential for teachers to consider which assessment tools to use to evaluate students' environmental literacy competencies and for policymakers to make decisions regarding the implementation of environmental literacy improvement efforts and how to assess them.

As future contributors to development, students must be equipped with environmental literacy competencies. Environmental literacy can be incorporated into formal education in relevant subjects [9]. In this context, the role of teachers is crucial in managing environmentally-based learning. Without environmental literacy, teachers may struggle to conduct environmentally-oriented learning activities [10,11]. Therefore, it is important to enhance environmental literacy competencies for prospective teachers within the formal education system at higher education institutions because students' environmental knowledge correlates with their attitudes and responsibilities outside the classroom [12]. According to Arif and Maryani [13], prospective teachers have a dual role: serving as behavioral role models for their students and contributing to the community's responsibility in solving environmental problems.

The increasing awareness of environmental education has led to various efforts to improve environmental literacy, including environmental literacy among future educators. The purpose of this research is to outline the trends in improving environmental literacy among teacher education students and to identify the assessments used in relevant articles. Therefore, the research questions (RQ) are formulated as follows:

RQ 1: What efforts are made to improve environmental literacy among prospective teachers?

RQ 2: What assessments are used to evaluate the environmental literacy competence of students?

2 Methodology

This research falls under the category of a systematic literature review. Data was obtained from Scopus metadata using the "Publish or Perish" (PoP) application. The search keywords used in this database search were "environmental literacy, pre-service teacher" and "environmental literacy, prospective teacher." The articles selected for analysis in this bibliometric study adhere to specific criteria: 1) Written in English, 2) Available in full text, 3) Published between 2014 and October 2023, 4) Targeted at teacher education students, 5) Sourced from journals or proceedings.

Through the PoP application, a total of 85 articles were obtained. Before processing the data, the database underwent a gradual reduction process with the following stages: 1) Selection of duplicate articles, 2) Selection based on titles, 3) Selection based on abstracts, 4) Selection based on full papers. The selection process is further elaborated in Figure 1

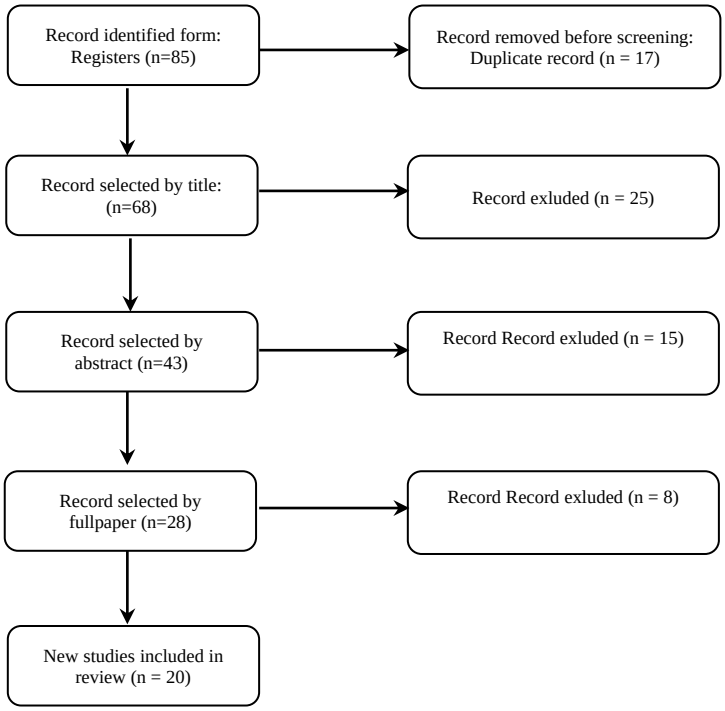

Figure 1. Literature Selection Flowchart.

The selected articles are those aimed at addressing the research questions formulated in the introduction section. The selected articles include journal articles, international seminar papers, and book chapters in proportions as shown in Table 1.

Table 1. Types of References Used.

No	Reference Type	Total
1.	Article journal	15
2.	Conferences	3
3.	Book chapter	1
4.	Data Paper	1

The obtained literature is systematically gathered based on the process of environmental literacy improvement and the assessments used. The proportions for each type of literature are displayed in Table 2.

Table 2. Proportions of the Environmental Literacy Improvement Process and Assessments Used.

Variables	Total Articles*
Improving environmental literacy competency for prospective teachers	9
Assessment used to evaluate the environmental literacy competency of prospective teachers	14

*) Several articles can be used as references for both variables

3 Results and Discussion

3.1 Research Mapping Related to Environmental Literacy in Prospective Teacher Students

Based on the explanations to answer RQ.1 and RQ.2, several methods have been identified that have been used to enhance the environmental literacy of prospective teacher students. This information is presented in Table 3.

Table 3. Summary of Efforts to Improve Environmental Literacy in Prospective Teacher Students.

No	Efforts to Increase Environmental Literacy	Author (s)
1	Providing material followed by real environmental problem solving projects	Deveci and Karteri (2020)
2	Providing material followed by a pedagogic project	Dada et al (2018)
3	Project learning using microcontroller technology	Artun (2016)
4	STEM-oriented learning	Sümen and Çalışıcı (2016) Kocak et al (2023)
5	Inquiry learning	Nkaizirwa et al (2023) Rasis et al (2023)
6	Problem-based learning	Saribaz et al (2016) Amini (2015)

Table 3 indicates that there are 8 methods gathered in this research as efforts to enhance the environmental literacy of prospective teacher students. These studies include research and development (R&D), survey research, and experiments. As for the instruments used in some relevant studies, they are summarized in Table 4.

Table 4. Summary of Efforts to Improve Environmental Literacy in Prospective Teacher Students.

No	The instruments used	Author (s)	Information
1.	Question	Santiani et al (2023)	Question true-false
2.	Questioner	Santiani et al (2023)	likert Scale
		Gwekwerere (2015)	Demographic questions, multiple choice, rating assessments, Likert scales, and comment boxes
		Artun (2016)	Environmental literacy scale
		Mashfufah et al (2018)	Online survey with values 1 and 0 for knowledge. Likert scale for aspects of attitudes, perceptions and concerns
3.	Interview	Gwekwerere (2015)	Reflect on some of the survey questions for more detailed information
4.	Mind Map	Sümen & Çalışıcı (2016)	Concept coding

Based on Table 4, it can be observed that several instruments are used to assess the environmental literacy of prospective teacher students. As previously explained in the

introduction, environmental literacy consists of multiple aspects, and each aspect can be assessed using different types of instruments.

3.2 RQ 1: How are Efforts to Improve Environmental Literacy Conducted in Higher Education?

The findings reveal significant efforts to improve environmental literacy among prospective teacher students. Saribas et al. [14] designed a 14-week course for elementary school teacher candidates, focusing on both environmental literacy and self-efficacy. The course structure involved multiple stages: understanding ecological principles and environmental challenges, selecting and analyzing environmental issues in small groups (including their causes, effects, and solutions), and concluding with reflective discussions. A 45-item environmental literacy scale was used to evaluate outcomes, encompassing four domains: environmental knowledge (11 items), attitudes (10 items), perceptions of environmental utilization (19 items), and environmental concern (9 items).

Dada et al. [15] explored how incorporating environmental education papers in teacher training programs influenced students' environmental literacy. Conducted at a university in New Zealand, the study lasted 12 weeks, with weekly 1-hour lectures and 2-hour workshops. The initial five weeks emphasized concepts such as biodiversity, sustainability, ecosystem interdependence, and global challenges, while the latter half focused on pedagogy and teaching strategies for environmental education. Findings showed a clear enhancement in environmental literacy, which correlated strongly with improved emotional engagement and attitudes.

Sümen and Çalışıcı [16] assessed the capacity of prospective teachers to implement a STEM-focused environmental literacy curriculum. The course incorporated a variety of activities and learning techniques, such as activity-based, simulation-based, and project-based learning, alongside cooperative learning. The topics included 1) Environmental Pollution Introduction, 2) Pollution Consequences, 3) Waste Decomposition Durations, 4) Recycling and Cost Analysis, and 5) Waste Management and Awareness Campaigns. Instructional methods ranged from creative drama for introducing pollution to simulation-based exploration of its effects. Waste decomposition was taught using problem-solving activities and mathematical integration. Participants created mind maps to illustrate their understanding of STEM and its relation to environmental concepts, which were evaluated for depth and connectivity.

Artun [17] implemented a mixed-methods study that used technology-assisted, project-based learning to evaluate environmental literacy among teacher candidates. Conducted over 14 weeks, the study engaged participants in projects utilizing tools such as TI-84 calculators, CBL systems, CO2 sensors, and humidity and temperature sensors. The projects addressed topics like air, water, and soil pollution, as well as waste management. Students worked 4-5 hours per session, 2-3 times weekly, and their work culminated in collaborative evaluations. Results showed a substantial increase in environmental literacy, with participants categorized as "innovators" or "early adopters" in Rogers' adoption model. None fell into the "early majority," "late majority," or "laggard" groups. The study further highlighted technology's positive role in enhancing environmental knowledge

Kocak et al [18] conducted research on STEM-based environmental education using microcontrollers and aimed to examine its impact on the environmental literacy of prospective teachers. The study involved a sample of 31 prospective teachers majoring in biology, science, and chemistry. The research spanned a total of 11 weeks, including training on microcontroller kits, STEM-based environmental education, and assessments. Participants were divided into several groups, with each group consisting of 4-5 members. The environmental material covered four stations: air pollution, water pollution, soil pollution,

light, and noise. Participants were expected to propose solutions using microcontroller kits. The research was conducted in four stages. First, during the initial 4 weeks, participants received training on microcontroller kits (kit components, how to use them, and how to write/find code). Second was the pre-test phase. Third, over a 5-week period, STEM-based environmental education was implemented. During this process, participants identified environmental issues in their daily lives, gathered information from various literature sources, and devised solutions using microcontrollers. The results indicated that STEM-based environmental education had a positive impact on the environmental literacy of prospective teachers. Prospective teachers' attitudes toward the environment improved. STEM-based environmental education enhanced prospective teachers' positive environmental behaviors, possibly because during the activities, prospective teachers proposed and designed solutions to environmental problems.

Nkaizirwa et al. [19] explored the use of inquiry-based learning to improve prospective teachers' understanding and attitudes toward environmental literacy. The study focused on themes such as the effects of rapid population growth on the environment and the impact of pollution on living organisms. It involved both experimental and control groups. The experimental group engaged in outdoor inquiry-based activities to investigate issues like waste management, campus environmental initiatives, resource conservation, and the handling of hazardous materials, including electronic waste, within a teacher training campus. These outdoor sessions were followed by reflective discussions in the classroom. On the other hand, the control group adhered to traditional teaching methods.

Similarly, research by [20] implemented an open inquiry-based learning kit to foster environmental literacy among biology education students. Developed using a research and development (R&D) approach with a 4D design process (define, design, develop, disseminate), this kit and its assessment tools underwent a rigorous validation process during the development stage. However, the results indicated that while the kit aimed to enhance environmental literacy, its impact on student outcomes, as measured by gain scores, was not significant.

Deveci and Karteri [21] conducted a Mixed Methods study utilizing Context-Based Learning supported by environmental assessment tools in science teacher education. This experimental research involved a single class and collected data through pretests and posttests. The intervention employed the REACT model (relating, experiencing, applying, cooperating, transferring) over a seven-week period, during which students worked in eight groups, each addressing a specific topic. Pretests were conducted in the first week, and posttests followed in the ninth week. The findings revealed that this context-based approach positively influenced prospective science teachers' confidence in environmental education and their environmental literacy. Qualitative data also highlighted growth in their environmental knowledge and self-assurance in teaching environmental topics.

Amini [22] developed an outdoor learning model known as Place-Based Learning Outdoors (PLO) to promote environmental education. This R&D study demonstrated that outdoor-based learning significantly improved students' outcomes, particularly their environmental awareness and concern for ecological issues.

3.3 RQ 2: What assessment tools were used?

Santiani et al [23] developed an environmental literacy assessment instrument called PPEL (The Palangka Raya peatlands sustainable environmental literacy). The instrument took the form of a questionnaire with eight stages. It was used to assess environmental literacy knowledge in a true-false format, consisting of 23 items. The attitude aspect was assessed using nine aspects with a Likert scale ranging from 1 to 4.

The assessment of students' ability to connect STEM with relevant concepts for integration can be done using a mind map task. Mind maps are used to determine the extent to which prospective teacher students can connect concepts into STEM. This research was conducted by [16]. The mind maps were coded for specific concept purposes. The codes within the mind maps were then organized according to the code themes, resulting in the grouping of concepts according to the code. A total of 46 codes were obtained, representing 46 concepts. This coding was subsequently analyzed by experts, and improvements were made based on expert feedback. Interviews with the student respondents indicated that this research helped students connect different fields of knowledge in the context of STEM and develop 21st-century environmental literacy skills. This training requires time and sustained use.

Gwekwerere [24] conducted a study to map environmental literacy, participation, and perceptions of prospective teachers regarding environmental education. The research utilized online surveys and interviews as data collection methods. A total of 84 students participated in the survey, while 15 were interviewed. The survey instrument was adapted from "The Young People and the Environment questionnaire" and included components such as (1) ecological and environmental knowledge, (2) sources of environmental knowledge, (3) concerns about environmental issues, (4) willingness to engage in environmental actions, and (5) beliefs and perceptions about teaching environmental education in schools. The survey consisted of demographic questions, multiple-choice questions, ranking assessments, Likert scale items, and comment boxes. Multiple-choice questions measured participants' understanding of environmental concepts, while ranking assessments sought opinions on environmental challenges in Canada and actions prospective teachers might take to address them. Likert scales evaluated participants' sources of environmental knowledge and their level of education on environmental topics. Comment boxes allowed participants to share their thoughts on environmental education. Interview questions, which were partly based on the survey, aimed to collect in-depth insights into the prospective teachers' environmental knowledge, attitudes, and perceptions about integrating environmental education into schools.

Artun [17] utilized both qualitative and quantitative data to collect the necessary information. Qualitative data were gathered through interview questions and the researcher's reflections, while quantitative data were collected using an environmental literacy scale. The environmental literacy scale consisted of 24 items with a five-point Likert scale. This instrument included both positive and negative statements. Subsequently, the data were analyzed and categorized according to Rogers' theory of innovation diffusion. The interviews comprised 10 questions. Both the environmental literacy scale and the interview questions were validated by experts before being administered to the respondents.

Mashfufah et al. [25] conducted research to evaluate the environmental understanding, attitudes, perspectives on utilization, and environmental concerns of prospective biology teachers during the 2016/2017 academic year at three universities in East Java. The study included 116 participants and used an online survey to assess four main aspects: knowledge (10 topics), attitudes (15 topics), perceptions of utilization (18 topics), and concerns about environmental issues (8 topics). Knowledge was scored dichotomously, with correct answers receiving a score of 1 and incorrect answers a score of 0. Meanwhile, attitudes, perceptions, and concerns were measured using a 5-point Likert scale. The findings indicated that better environmental knowledge correlated with stronger beliefs and concerns about environmental issues, while more favorable attitudes aligned with heightened environmental awareness.

Kroufek et al. [26] investigated the environmental literacy of future preschool educators in the Czech Republic and Turkey using the Environmental Literacy Scale for Adults (ELSA). This scale encompasses 20 items across three dimensions: consciousness,

awareness, and anxiety. The study explored possible links between environmental literacy levels and factors such as participants' ages or the duration of their studies.

Kocak et al. [18], in their study on microcontroller-assisted environmental education, assessed four facets of environmental literacy: knowledge, attitudes, behaviors, and awareness. The evaluation consisted of 61 questions, including 20 multiple-choice questions for knowledge, scored as either 1 (correct) or 0 (incorrect). The attitude dimension included 18 questions measured on a 5-point Likert scale. The behavioral component was assessed with 20 questions using a 3-point Likert scale, while awareness was gauged with 3 questions on a Likert scale.

Nkaizirwa et al. [19] explored how inquiry-based learning influenced the environmental knowledge and attitudes of prospective biology teachers. Environmental attitudes were examined using the Two-MEV ecological attitude model, focusing on preservation and utilization dimensions. Environmental knowledge was assessed through Roczen et al.'s Competency Model for Environmental Education, which measures three dimensions: systems knowledge, action-oriented knowledge, and effectiveness knowledge. The study employed a pre-test and post-test design, comparing results between experimental and control groups.

Tuncer Teksoz et al. [27] analyzed students' environmental literacy through Rasch modeling. The study utilized various instruments, including a knowledge test, an attitude scale, an environmental responsibility scale, and a concern scale. The knowledge test comprised 12 multiple-choice items, with an "I don’t know" option to reduce the impact of random guessing. Attitudes were assessed using a 5-point Likert scale. The environmental responsibility scale included 19 items, addressing individual accountability (item 8), governmental obligations (items 2, 9, 13), landowner duties (item 5), and collective societal responsibilities (items 1, 4, 6, 10–12, 14, 17–19). The concern scale, featuring eight items rated on a 5-point scale, gauged participants’ sensitivity to environmental issues. In total, the research covered 51 measurement items across the domains of knowledge, attitudes, responsibility, and concern.

Dada et al. [15], in their study examining the impact of environmental education materials on students' literacy, evaluated environmental knowledge, attitudes, behaviors, and awareness. Knowledge was measured using multiple-choice questions with five options, scoring +1 for correct responses, -1 for incorrect responses, and 0 for unanswered items. Attitudes were assessed using a survey instrument that included components such as locus of control, responsibility, and worldviews about environmental issues, with responses recorded on a 5-point Likert scale. Awareness was also evaluated through a 1-5 Likert scale, addressing topics like water pollution, climate change, waste management, endangered species, social issues, and biodiversity loss. Lastly, behavior was assessed using a similar 5-point Likert scale, focusing on environmentally conscious actions.

Dolenc Orbanić and Kovač [28] explored aspects of environmental literacy among future preschool and elementary school teachers. Their questionnaire comprised three sections: (a) environmental awareness, (b) attitudes and behaviors, and (c) perceptions of environmental education. The first section included three open-ended questions and a Likert scale with 30 statements to evaluate awareness. The second section used a 5-point Likert scale with 22 statements to investigate attitudes and behaviors, with eight items addressing the human-nature relationship and responsibility for environmental issues, while 14 items assessed eco-friendly actions in daily routines. The final section explored perspectives on environmental education through four questions, focusing on the societal significance of literacy, trusted information sources, the role of environmental education in schools, and the adequacy of knowledge gained during their studies.

Deveci and Karteri [21] carried out a mixed-methods study on the application of context-based learning using environmental evaluation tools in science teacher education. The study

employed several instruments, including an Environmental Literacy Scale, a self-efficacy questionnaire, and interviews. The Environmental Literacy Scale comprised 20 items spanning three dimensions: awareness, concern, and consciousness related to environmental issues. The self-efficacy instrument contained 24 items measuring both content mastery and pedagogical strategies. Additional insights into participants' views on environmental literacy and self-efficacy were gathered through interviews. Fettahlıoğlu et al. [29] modified the Environmental Affective Tendency Scale, originally developed by Yavetz, Goldman, and Pe'er (2009), and adapted it for Turkish contexts. The scale was validated for reliability and used a 1-5 Likert scale to measure environmental attitudes effectively.

Husamah et al. [30] introduced an Environmental Literacy Instrument (ELIS) designed specifically for prospective science teachers and incorporating a spiritual dimension. This tool consisted of 26 items and demonstrated satisfactory internal validity and reliability. The instrument covered four dimensions: ecological knowledge (five items), environmental expectations (seven items), cognitive skills (eight items), and behavior (six items), all presented in the format of a questionnaire.

4 Conclusion

The results of this research show that the forms of environmental literacy improvement courses used in higher education are: 1) providing materials followed by real environmental problem-solving projects, 2) providing materials followed by pedagogic projects, 3) project-based learning using microcontroller technology, 4) STEM-oriented learning, and 5) inquiry-based learning. The instruments used include multiple-choice tests, interviews, and questionnaires. Environmental literacy improvement-oriented learning is widely applied to students majoring in elementary education, science education, and biology education.

References

1. D. K. Ram, U. Gautam, D. B. Tewari, L. T. Pham, J. J. L. Tenerife, "Environmental literacy and attitudes of self-efficacy in environmental education", J. of Positive School Psychology, **6**(3), 4133–4137 (2022).
2. T. Evers, Wisconsin Standards for Environmental Literacy and Sustainability. Wisconsin Department of Public Instruction, (2018).
3. E. Özdil and A. Y. Çelik, "Environmental Literacy: Comparison between Chemistry Teacher Candidates, Chemistry Teachers, and Individuals in Environmentally Related Professions", Int. J. of Edu. Res. Rev, **7**(4), 366–379 (2022).
4. R. Szczytko, K. Stevenson, M. N. Peterson, J. Nietfeld, R. L. Strnad, "Development and validation of the environmental literacy instrument for adolescents", Environ. Edu. Res., **25**(2), 193–210 (2019).
5. R. H. Hunter and R. C. Jordan, "The TELA: A New Tool for Assessing Educator Environmental Literacy", Interdisciplinary J. of Environ. and Sci. Edu, **15**(1), 1–9 (2019).
6. M. Ulfah, S. Suyanto, T. Aminatun, "The completeness of environmental literacy aspects studied in the articles published in several countries", JPBI (J. Pend.Biol. Ind), **6**(1), 75–82 (2020).
7. H. Spínola, "Correlations between environmental literacy components (knowledge, attitude and behavior) in Madeira Island (Portugal) 9th grade students", The Online J. of New Horizons in Edu, **10**(1), 28–36 (2020).
8. A. Pujiati, K. Setiaji, S. Oktavilia, "Impact of Social Influence and Environmental Literacy on Green Consumption Behaviour: A case study of Indonesian students", Int.

J. of Advanced Science and Technology, **29**(6), 6510–6515 (2020).
9. E. Gheith, "Environmental literacy among prospective classroom teachers in Jordan", Int. J. of Learn. Teach. and Edu. Res, **18**(12), 258–279 (2019).
10. S. Y. Liu, S. C. Yeh, S. W. Liang, W. T. Fang, H. M. Tsai, "A national investigation of teachers environmental literacy as a reference for promoting environmental education in Taiwan", J. of Environ. Edu, **46**(2), 114–132 (2015).
11. S. W. Liang, W. T. Fang, S. C. Yeh, S. Y. Liu, H. M. Tsai, J. Y. Chou, E. Ng, "A nationwide survey evaluating the environmental literacy of undergraduate students in Taiwan", Sustainability (Switzerland), **10(**6), 1–21 (2018).
12. J. Kuruppuarachchi, V. Sayakkarage, B. Madurapperuma, "Environmental literacy level comparison of undergraduates in the conventional and odls universities in Sri lanka", Sustainability (Switzerland), **13**(3), 1–16 (2021).
13. M. Arif and E. Maryani, "Analysis of Environmental Literacy Profile Indonesian Students at STKIP Pesisir", J. Geografi, **15**(2), 259–271 (2023).
14. D. Saribas, Z. D. Kucuk, H. Ertepinar, "Implementation of an environmental education course to improve pre-service elementary teachers' environmental literacy and self-efficacy beliefs", Int. Res. in Geographical and Environ. Edu, **26**(4), 311–326 (2016).
15. D. O. Dada, C. Eames, N. Calder, "Impact of Environmental Education on Beginning Preservice Teachers' Environmental Literacy", Aust J. of Environ.Edu**, 33**(3), 201–222 (2017).
16. Ö. Ö. Sümen and H. Çalışıcı, "Pre-service teachers' mind maps and opinions on STEM education implemented in an environmental literacy course", Kuram ve Uygulamada Egitim Bilimleri, **16**(2), 459–476 (2016).
17. H. Artun, "Examining the influence of projects carried out with technological tools on pre-service teachers' levels of environmental literacy", J. of Baltic Sci. Edu, **15**(2), 173–184 (2016).
18. E. Kocak, A. Y. Çelik, C. Uluyol, "Pre-service Teachers' Environmental Literacy: The Role of STEM-Based Environmental Education with Microcontrollers", Participatory Edu.Res, **10**(5), 233–247 (2023).
19. J. P. Nkaizirwa, C. M. Aurah, F. Nsanganwimana, "Data collected to assess the effect of inquiry-based learning on environmental knowledge and attitudes among pre-service biology teachers in Tanzania", Data in Brief, **49**, 109429 (2023).
20. R. Rasis, Paidi, Suhartini, H. Kuswanto, R. D. Hartanti, "The Effect of Environmental Education Open Inquiry Learning Kits on the Environmental Literacy of Pre-service Biology Teachers", J. of Teacher Edu. for Sustainability, **25**(1), 40–63 (2023).
21. I. Deveci and I. Karteri, "Context-Based Learning Supported by Environmental Measurement Devices in Science Teacher Education: A Mixed Method Research", J. of Biological Edu, **56**(5), 487–512 (2022).
22. R. Amini, "Outdoor based environmental education learning and its effect in caring attitude toward environment", J. Pend. IPA Ind., **4**(1), 43–47 (2015).
23. S. Santiani, A. Rusilowati, S. Sudarmin, S. Ngabekti, "Fit-Model Sustainable Competencies of Palangka Raya Indonesia Peat Lands in the Environmental Literacy (P-PSEL) Questionnaire for Teacher-Candidates", Polish J. of Environ. Stud., **32**(2), 1781–1788, (2023).
24. Y. Gwekwerere, "Pre-service teachers' knowledge, participation and perceptions about environmental education in schools", Aust. J. of Environ.Edu, **30**(2), 198–214, (2015).
25. A. Mashfufah, J. Nurkamto, Sajidan, Wiranto, "Environmental literacy among biology pre-service teachers: A pilot study", AIP Conference Proceedings, (2018).
26. R. Kroufek, C. Çelik, S. Can, "The Comparison of Environmental Literacy of Czech and Turkish pre-service primary teachers using Elsa Scale", Turk. Online J. Educ. Technol, September, (2015).

27. G. Teksoz, J. W. Boone, O. Y. Tuzun, C. Oztekin, "An evaluation of the environmental literacy of preservice teachers in Turkey through Rasch analysis", Environ.Edu.Res., **20**(2), 202–227 (2014).
28. N. D. Orbanić and N. Kovač, "Environmental awareness, attitudes, and behaviour of preservice preschool and primary school teachers", J. of Baltic Sci. Edu, **20**(3), 373–388 (2021).
29. P. Fettahlıoğlu, S. Timur, B. Timur, "Environmental affective dispositions scale (EADS): The study of validity and reliability and adaptation to Turkish", Int.J. of Environ. and Sci. Edu, **11**(10), 3179–3199 (2016).
30. H. Husamah, H. Suwono, H. Nur, A. Dharmawan, "The development and validation of environmental literacy instrument based on spirituality for prospective science teachers", Eur. J of Math., Sci. and Tech. Edu, **18**(12) (2022).