



INTERNATIONAL JOURNAL OF
MODERN EDUCATION
(IJMOE)

www.gaexcellence.com/ijmoe



ENVIRONMENTAL LITERACY AND PRO- ENVIRONMENTAL BEHAVIOR AMONG SECONDARY SCHOOL STUDENTS: A NARRATIVE REVIEW OF ENVIRONMENTAL KNOWLEDGE, ENVIRONMENTAL ATTITUDES, ACTION COMPETENCE, AND PRO- ENVIRONMENTAL BEHAVIORAL PRACTICES

Yu Sun¹, Mohammad Ismath Ramzy Mohammad Ismail^{2*}, Abd Razak Zakaria³

¹Faculty of Education, Universiti Malaya, Malaysia

 s2170446@siswa.um.edu.my

 <https://orcid.org/0009-0009-0258-9051>

²Faculty of Education, Universiti Malaya, Malaysia

 ismathramzy@um.edu.my

 <https://orcid.org/0000-0001-5676-1114>

³Faculty of Education, Universiti Malaya, Malaysia

 abdrzak@um.edu.my

 <https://orcid.org/0000-0003-1136-6625>

*Corresponding Author

Article Info:

Article history:

Received date: 30.07.2026

Revised date: 19.08.2026

Accepted date: 27.09.2026

Published date: 30.09.2026

To cite this document:

Yu, S., Ismail, M. I. R. M., & Zakaria, A. R. (2026). Environmental Literacy and Pro-Environmental Behavior among Secondary School Students: A Narrative Review of Environmental Knowledge, Environmental Attitudes, Action competence, and Pro-environmental Behavioral

Abstract:

Environmental literacy is essential for secondary school students to understand environmental issues and engage in pro-environmental behavior. Students need to develop relevant environmental knowledge, environmental attitudes, action competence, and behavioral practices to respond to current and future environmental challenges. However, there is a gap between students' environmental awareness and their actual environmental behavior. Previous research has shown that environmental knowledge and positive attitudes do not always lead to meaningful and sustained pro-environmental action. Hence, this research aims to explore environmental literacy and pro-environmental behavior among secondary school students. This research reviewed previous studies identified from Web of Science, Scopus, ERIC, and Google Scholar. The following keywords were used to search articles from academic journals: environmental literacy, environmental knowledge, environmental attitudes, action competence, environmental behavior, pro-environmental behavior, secondary school students, and environmental education. This study used a narrative review to explore environmental literacy and pro-environmental behavior among secondary school students. The review included 55 academic articles. Based on the thematic analysis, the findings were grouped into

Practices. *International Journal of Modern Education*, 8(31), 1858-1880.

environmental knowledge, environmental attitudes, action competence, and pro-environmental behavioral practices and showed that environmental knowledge provides a cognitive foundation, while positive attitudes alone do not necessarily translate into action. Action competence helps bridge this gap, whereas behavioral practices are associated with individual, social, and contextual conditions. Action-oriented approaches, including outdoor education, citizen science, and service learning, may further support the translation of environmental knowledge into pro-environmental behavior. This research recommends that schools integrate environmental knowledge with practical experience and meaningful participation through action-oriented environmental projects, outdoor activities, community engagement, citizen science, and school sustainability initiatives, thereby preparing environmentally literate students to translate environmental knowledge and attitudes into responsible environmental action.

DOI: 10.35631/IJMOE.831108

Keyword:

Action Competence, Environmental Literacy, Environmental Knowledge, Environmental Attitudes, Pro-Environmental Behavior



© The authors (2026). This is an Open Access article distributed under the terms of the Creative Commons Attribution (CC BY NC) (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact ijmoe@gaexcellence.com.

Introduction

Environmental degradation, climate change, biodiversity loss, and resource depletion have become pressing global concerns that require corresponding educational responses. Schools are increasingly recognized as important settings for cultivating environmentally responsible citizens by providing students with opportunities to develop environmental knowledge, attitudes, competencies, and pro-environmental practices (Huoponen, 2024). Among different educational stages, secondary education is particularly important because adolescence represents a formative period in which various individual and contextual factors shape students' engagement in pro-environmental behavior (Denault et al., 2024). Recent research has further demonstrated that environmental and species-related knowledge is associated with secondary school students' environmental attitudes (Härtel et al., 2023), while environmental attitudes, self-efficacy, knowledge, and other psychosocial factors may contribute to adolescents' pro-environmental intentions and behaviors (Denault et al., 2024; Qin et al., 2024). Therefore, strengthening environmental knowledge, practical environmental skills, and positive environmental attitudes that support environmentally responsible behavior remains an important objective of environmental education at the secondary school level.

Environmental literacy is necessary for secondary school students to understand environmental issues and respond to environmental challenges. The existing literature provides information on environmental literacy among students in different educational contexts (Guerrero & Sjöström, 2025; Hermawan et al., 2022; Huang et al., 2022; Rahma et al., 2026). However, previous studies have often examined individual dimensions of environmental literacy, particularly environmental knowledge and attitudes, rather than explaining how multiple dimensions work together and relate to students' actual pro-environmental behavior. In particular, there remains insufficient explanation of why relatively high levels of environmental knowledge or positive environmental attitudes do not necessarily translate into consistent environmental action among secondary school students. Further, more studies are needed to provide information on environmental knowledge, environmental attitudes, action competence, and behavioral practices, and to identify how these dimensions are connected among secondary school students (Huoponen, 2024, 2025; Kabylbek et al., 2025). Clarifying these connections is important for understanding how environmental literacy can be translated into meaningful and sustained pro-environmental practices. According to Xiong et al. (2025), environmental literacy in secondary education involves multiple dimensions and should not be limited to environmental knowledge alone. These dimensions include environmental knowledge, attitudes, skills, participation, and environmentally responsible behavior. These dimensions may develop differently according to educational context, school experience, and environmental topic. Secondary school students possess different levels of environmental knowledge that are essential for understanding environmental problems and making environmental decisions. This knowledge includes ecological knowledge, biodiversity knowledge, climate-change knowledge, and knowledge related to waste, water, and energy issues (M. Aydin et al., 2023; Härtel et al., 2023).

Further, the existing research highlights that environmental education needs to assist students in developing environmental literacy and pro-environmental behavior (Van De Wetering et al., 2022). Environmental literacy is essential for understanding environmental problems and participating in environmentally responsible practices. Further, environmental education needs to fill the perceived gap between environmental awareness and environmental action; that is, students need to be equipped with relevant knowledge, attitudes, competence, and opportunities to act. The gap remains evident, as positive environmental attitudes do not always lead to consistent pro-environmental behavior among adolescents (Huoponen, 2024). Existing research has not sufficiently integrated environmental knowledge, attitudes, action competence, and behavioral practices to explain this gap, particularly in the context of secondary education. If this gap persists, students may have environmental awareness but remain less involved in meaningful environmental action. Further, Olsson et al. (2022) stated that education for sustainable development needs to support students' action competence and provide opportunities to participate in sustainability-related issues. Enhancing environmental knowledge is not enough; students need to be introduced to and involved in environmental problems through practical experience, decision-making, and participation. This will assist them in developing confidence, willingness, and competence to respond to environmental challenges. Hence, it is essential to identify the current characteristics of environmental literacy among secondary school students based on environmental knowledge, environmental attitudes, action competence, and pro-environmental behavioral practices. Since environmental behavior is influenced by individual, social, contextual, and educational factors, it is necessary to identify the factors and educational approaches that can strengthen environmental literacy and pro-environmental behavior among secondary school students.

Therefore, there is a need to review the existing literature systematically through a narrative approach to provide an integrated understanding of environmental literacy and pro-environmental behavior among secondary school students. Specifically, this review focuses on four key dimensions of environmental literacy: environmental knowledge, environmental attitudes, action competence, and pro-environmental behavioral practices. This review reveals evidence on their interconnections, with particular attention to the gap between environmental knowledge and attitudes and students' actual pro-environmental behavior. Further, the review considers the individual, social, contextual, and educational factors that influence these dimensions and the educational approaches that support their development. This narrative review aims to examine the key dimensions of environmental literacy among secondary school students, including environmental knowledge, attitudes, action competence, and behavioural practices, identify individual, social, contextual, and educational factors associated with pro-environmental behaviour, examine the knowledge and behaviour gap, and synthesize educational approaches that may support the translation of environmental knowledge and attitudes into meaningful environmental action.

Methodology

This study applied the narrative review to explore environmental literacy and pro-environmental behavior among secondary school students. According to Ferrari (2015) and Sony et al. (2020), a narrative review is a comprehensive, critical, and focused analysis of current knowledge on a particular topic. Also, compared to systematic reviews, narrative reviews do not follow strictly standardized guidelines. This study applied a narrative review, because it was difficult to pool the data statistically due to the different research designs, measurements, educational contexts, and analysis techniques applied in the studies (Crea-Arsenio et al., 2022). Narrative reviews can provide an integrated understanding of a specific topic and identify areas for future research (Mgaiwa, 2021). Based on this methodology, the narrative review aimed to identify the common themes related to environmental literacy and pro-environmental behavior among secondary school students and suggest new research areas for future work. Thematic analysis was used to explore and generate the results of the narrative review.

Procedures

This study used databases including Web of Science, Scopus, ERIC, and Google Scholar to search for relevant literature. The keywords used in this study were environmental literacy, environmental knowledge, environmental attitudes, action competence, environmental behavior, pro-environmental behavior, secondary school students, high school students, middle school students, and environmental education. The keywords and their corresponding categories used in the literature search are summarized in Table 1. Before the analysis, articles were accessed and reviewed for relevance and inclusion as data sources. The inclusion process involved four standards to select articles: (1) articles from refereed journals; (2) articles focusing on secondary school, high school, or middle school students; (3) studies examining environmental literacy, environmental knowledge, environmental attitudes, action competence, pro-environmental behavior, or relevant environmental education approaches; and (4) articles published in English between 2015 and 2026. Publications unavailable in full text were excluded from the analysis; papers that did not provide relevant research on environmental literacy or pro-environmental behavior were also eliminated by the researcher to align with the specific research goals of the study. Studies focusing exclusively on university students,

primary school students, teachers, or adult populations without relevant secondary school student data were excluded from the analysis. The scope of analysis was limited to environmental knowledge, environmental attitudes, action competence, behavioral practices, their influencing factors, and educational approaches among secondary school students. Based on the analysis, the researcher developed themes accordingly. The database searches initially identified a broad pool of potentially relevant records. After duplicate records were removed, titles and abstracts were screened according to the predefined eligibility criteria. Studies that did not focus on the target population or did not address environmental literacy, its key dimensions, pro-environmental behavior, or relevant educational approaches were excluded. The remaining potentially eligible articles underwent full-text assessment, after which 55 academic articles meeting the inclusion criteria were retained for the narrative synthesis.

Table 1: Key Search Terms

Database	Search terms
Web of Science	("secondary school*" OR "high school*" OR adolescent*) AND ("environmental knowledge" OR "environmental skill*" OR "environmental attitude*" OR "environmental literacy" OR "pro-environmental behavior" OR "environmental behavior") AND ("environmental education" OR "sustainability education")
Scopus	("secondary school*" OR "high school*" OR adolescent*) AND ("environmental knowledge" OR "environmental skill*" OR "environmental attitude*" OR "environmental literacy" OR "pro-environmental behavior" OR "environmental behavior") AND ("environmental education" OR "sustainability education")
ERIC	("Secondary School Students" OR "High School Students" OR Adolescents) AND ("Environmental Education" OR Sustainability) AND (Knowledge OR Skills OR Attitudes OR Behavior)
Google Scholar	"secondary school students" ("environmental knowledge" OR "environmental attitudes" OR "environmental skills" OR "pro-environmental behavior")

Research Questions

Following the structure of the reference narrative review, this study addresses the following research questions:

- RQ1. What are the current characteristics of environmental literacy among secondary school students in terms of environmental knowledge, environmental attitudes, action competence, and pro-environmental behavioral practices?
- RQ2. What individual, social, contextual, and educational factors influence environmental literacy and pro-environmental behavior among secondary school students, and what educational approaches have been found to strengthen these outcomes?

Findings

The main themes derived from the narrative analysis were clustered into three interrelated topics: (i) characteristics of environmental literacy among secondary school students; (ii) action

competence and pro-environmental behavioral practices; (iii) determinants of environmental literacy and educational approaches that strengthen environmental action. The 55 reviewed articles were classified using the database-based codes established during the literature search (W = Web of Science, S = Scopus, E = ERIC, and G = Google Scholar). The coding system was used to compare findings across studies and to identify recurring patterns in environmental knowledge, environmental attitudes, cognitive and action-oriented competence, and actual or intended pro-environmental behavior, and revealing research gaps and implications for future environmental education.

The researcher classified each article with a particular code for easy access. Table 2 shows selected articles from relevant databases with codes defined by the researcher. The articles have been categorized based on the particular database.

Table 2: Article With Relevant Codes

Database	Code	Reference
1	WoS	W1: Mónus (2022); W2: Olsson et al. (2022); W3: Torsdottir et al. (2024); W4: Härtel et al. (2023); W5: Liao & Li (2019); W6: Sieg & Dreesmann (2021); W7: Neurohr et al. (2024); W8: Bezeljak et al. (2023); W9: Arı & Yılmaz (2017); W10: Chao (2024); W11: Masson et al. (2025); W12: List et al. (2020); W13: Xiong et al. (2025); W14: Radzi et al. (2022); W15: Chen & Liu (2020); W16: Sass et al. (2020).
2	Scopus	S1: Kellberg et al. (2023); S2: Nurwido et al. (2020); S3: Wardani et al. (2018); S4: Prasetyo et al. (2020); S5: Khairani et al. (2020); S6: Ganatsa et al. (2021); S7: E. Aydin et al. (2022); S8: Abd Wahab & Mapa (2021); S9: Wandera et al. (2022); S10: Abd Hamid et al. (2021); S11: Razak et al. (2019); S12: Akçay & Şengül (2023); S13: Susanti & Nupus (2022); S14: Mahayuddin et al. (2024); S15: Cahyani et al. (2025); S16: Mustafaoğlu & Alkan (2025); S17: Brumann et al. (2022).
3	ERIC	E1: Gibson et al. (2024); E2: van Harskamp et al. (2024); E3: López-Fernández et al. (2024); E4: Harris et al. (2023); E5: Schneller et al. (2022); E6: Frensley et al. (2022); E7: Verhelst et al. (2022); E8: Gladwin et al. (2022); E9: Bayati (2023); E10: Mongar (2023); E11: Araújo et al. (2023); E12: Aruta (2023).
4	Google Scholar	G1: Eze (2020); G2: Dela Peña et al. (2019); G3: El Batri et al. (2019); G4: Amahmid et al. (2019); G5: Marcum-Dietrich et al. (2021); G6: Duggan et al. (2021); G7: Leckey et al. (2021); G8: Troy Frensley et al. (2020); G9: Covitt et al. (2021); G10: Yalçınkaya & Çetin (2018).

Characteristics of Environmental Literacy among Secondary School Students

Environmental literacy was generally treated as a multidimensional construct. Across the reviewed studies, the most frequently measured components were ecological or environmental knowledge, environmental attitudes or affect, cognitive skills, action competence, and pro-environmental behavior. Studies using environmental-literacy frameworks such as middle school environmental literacy survey explicitly combined ecological knowledge, environmental affect, cognitive skills, and behavior (S2), while other studies assessed knowledge, attitudes, and cognitive skills separately (S3, S4). This pattern indicates that the

literature increasingly conceptualizes environmentally literate students as those to understand environmental issues, interpret them, evaluate possible responses, and translate dispositions into action.

Environmental knowledge was the most consistently examined dimension. The reviewed studies addressed general ecological knowledge, climate-change knowledge, biodiversity and species knowledge, waste-management knowledge, water-use knowledge, and energy-related science literacy (W4, W5, W12, W14, S5, S7, S10, S14, E12, G3, G4). However, students' knowledge levels were not uniformly high. Some descriptive studies reported moderate environmental knowledge and weaknesses in issue analysis or applied reasoning (S3, S4), whereas context-specific studies showed stronger knowledge in familiar domains such as biodiversity or 3R (that is Reduce, Reuse, and Recycle) waste management (S5, S14). W4 further showed that species knowledge contributed to environmental system knowledge and environmental attitudes, suggesting that specific ecological knowledge can function as a foundation for broader environmental understanding.

Environmental attitudes and affect were generally more positive than students demonstrated action-oriented competence. Positive attitudes were reported in studies concerning biodiversity, marine litter, climate change, conservation, and general environmental protection (W4, S5, E9, E11, G10). However, positive attitudes did not always correspond to equally strong cognitive skills or behavioral performance. S4, for example, reported comparatively weak attitudes and issue-analysis skills in a high-school sample, while S2 showed that environmental-literacy dimensions varied by school type and grade. These findings suggest that environmental literacy should not be interpreted from attitude scores alone.

Differences by demographic and educational context were also recurrent. Gender differences were reported in several studies, often with female students demonstrating stronger environmental literacy, knowledge, or attitudes (S5, S12). Grade level was associated with some dimensions, particularly cognitive skills (S2), whereas school type, study stream, and school environmental policy also produced differences (W1, S2, S11). As shown in Table 3, these patterns suggest that environmental literacy is shaped not only by individual learning but also by the institutional and curricular environments in which students encounter sustainability issues.

Table 3: Characteristics Of Environmental Literacy Among Secondary School Students

Dimension	Article codes	Narrative synthesis
Environmental knowledge	W4, W5, W12, W14, S2, S3, S4, S5, S7, S10, S11, S12, S13, S14, S15, E9, E12, G3, G4, G9	Knowledge ranges from general ecological concepts to biodiversity, climate, waste, water, energy, and local environmental systems. Levels are often moderate and topic-dependent; applied knowledge is weaker than factual awareness in several studies.
Environmental attitudes	W1, W4, W6, W8, S2, S3, S4, S5, S6, S10, S11, S12, S15, S16, E9, E11, G1, G2, G10	Students commonly express concern and positive environmental attitudes, but affective support does not consistently predict or translate into action.

Dimension	Article codes	Narrative synthesis
Environmental cognitive skills	W15, W16, S2, S3, S4, S17, E2, E7, G5, G9	Issue identification, analysis, evaluation of alternatives, systems thinking, and decision-making are less frequently measured and often less developed than knowledge or attitudes.
Environmental action competence	W2, W3, W15, W16, E2, E7, E10, G6	Action competence includes knowledge, willingness, self-efficacy, strategic thinking, and experience in taking action. School opportunities to influence real issues are important but remain limited.
Pro-environmental behavioral practices	W1, W5, W6, W9, W10, W7, S1, S2, S6, S9, S10, S14, S15, S16, E1, E5, E12, G1, G2, G3, G4	Behavior includes recycling, waste separation, energy conservation, biodiversity protection, water conservation, outdoor stewardship, civic participation, and self-reported general ecological behavior. Intentions are measured more often than objectively observed behavior.

Action Competence and Pro-Environmental Behavioral Practices

The reviewed studies show that the transition from environmental awareness to pro-environmental behavior is not automatic. Knowledge can support action, but the relationship is often mediated or conditioned by attitudes, perceived efficacy, social norms, identity, interest, and opportunities to act. W5 found environmental knowledge to be an important predictor of students' solid-waste separation intention, but subjective norms could constrain participation despite positive attitudes. E12 similarly showed that science literacy supported household energy-conservation behavior through climate-change knowledge efficacy. These studies demonstrate that knowledge becomes behaviourally meaningful when students believe that their knowledge can be used effectively.

Action competence emerged as a particularly important bridge between learning and behavior. W15 and W16 conceptualized action competence as more than compliance with prescribed environmentally friendly acts; it involves knowledge, willingness, confidence, strategic understanding, and the capacity to make informed choices. W3 showed that students had relatively few school experiences of influencing society, yet such experiences were positively related to self-perceived action competence. E7 further indicated that school-level organizational conditions, including sustainable leadership, pluralistic communication, adaptability, and democratic decision-making, were associated with student knowledge and willingness. The reviewed literature therefore suggests that environmental education becomes more action-oriented when students are allowed to deliberate, participate, and experience influence.

Behavioral practices were highly context specific. Recycling and waste separation were prominent in W5, S14, and S16; energy conservation appeared in S1 and E12; biodiversity-related behavior and conservation were examined in W4, W6, W11, and E4; and water-related knowledge and practices were addressed in G4 and E11. W7 linked students' interest in nature and nature activities with self-reported general ecological behavior, while W8 showed that time outdoors and positive emotions toward nature supported connectedness with nature, a factor closely associated with Pro-environmental behavior (PEB). In this sense, the evidence points

to behavioral specificity: students may show strong behavior in one domain while remaining less engaged in another.

A recurring concern is the distinction between behavioral intention and sustained behavior. W6 reported an increase in pro-environmental behavioral intentions immediately after a hands-on bumblebee intervention, but the gain was not maintained at follow-up. S1 found increased willingness to act following an identity-oriented energy-transition exhibition, while E5 reported short-term improvements in pro-environmental behavior and civic engagement through urban ecojustice service learning. Together, as shown in Table 4, these findings indicate that interventions can activate willingness and short-term action, but sustained behavioral change requires continued opportunities, reinforcement, and supportive contexts.

Table 4 : Action Competence And Pro-Environmental Behavioral Practices

Cluster	Outcomes	Article codes
Foundational literacy	Environmental knowledge; biodiversity and species knowledge; climate and energy knowledge; waste and water knowledge	W4, W5, W12, W14, S3, S4, S5, S7, S10, S14, E12, G3, G4
Affective orientation	Environmental concern; positive attitudes; environmental affect; interest in nature; connectedness with nature; environmental identity	W1, W4, W6, W7, W8, S5, S6, E9, S1, G10
Action-oriented competence	Issue identification; issue analysis; planning; willingness; self-efficacy; systems and strategic thinking; participation	W3, W15, W16, S2, S3, S4, E2, E7, E10, G5, G6
Private-sphere PEB	Recycling; waste separation; reusing; household energy conservation; water conservation; consumption choices	W5, S14, S16, E3, E12, G4
Public PEB	Citizen science; service learning; environmental citizenship; civic engagement; community action; influencing society	W3, W11, E1, E2, E3, E4, E5, E7, E8, E11, G6, G7

Determinants and Educational Approaches Supporting Environmental Literacy and PEB

The second research question focused on factors and educational approaches that influence environmental literacy and pro-environmental behavior. As shown in Table 5, the outcomes reflect the combined effects of knowledge, attitudes, psychological factors, social influences, school organization, socioeconomic background, and learning experiences. W1 identified school environmental-education policy and socioeconomic background as relevant to students' attitudes and PEB. W5 emphasized the role of subjective norms, while W7 and W8 highlighted nature connectedness, time spent outdoors, and interest in nature. E9 showed that scientific knowledge, human-nature perceptions, and personal motivations were important for attitudes toward ecological issues. These findings support a multilevel understanding of environmental behavior.

School-based environmental education was generally beneficial, although program effects varied across literacy dimensions. S2 reported that participation in the Adiwiyata Eco-School context was associated with differences in ecological knowledge, behavior, affect, and cognitive skills, with grade-level differences particularly evident for cognitive skills. G3

demonstrated that a targeted science-syllabus intervention could promote environmental knowledge and behavior, while E10 reported that environmental science in Bhutanese secondary schools supported optimism, stewardship, agency, and more positive environmental behavior, even though anthropocentric perspectives remained.

Experiential, inquiry-based, place-based, and citizen-science approaches were prominent among more recent studies. W6 used direct interaction with living bumblebees to connect biodiversity knowledge, interest, attitudes, and behavioral intentions. E4 showed that repeated outdoor interaction with a local organism strengthened ecological place meaning and attachment among urban adolescents. E11 found that participation in a coastal citizen-science project produced positive changes across multiple dimensions of students' environmental attitudes. G5 used data-rich watershed learning and technology to support interest in watershed action, while S17 developed a close-to-science inquiry-based climate-change learning environment. These studies suggest that environmental literacy is strengthened when abstract environmental issues are made local, observable, investigable, and personally meaningful.

Action-oriented and participatory pedagogies also appear critical for developing competence beyond knowledge acquisition. W3 and E7 emphasize school experiences that allow students to influence decisions or participate democratically. E5 demonstrates the potential of service learning and ecojustice education to connect environmental issues with civic engagement and social justice. S1 indicates that socio-scientific museum experiences can increase students' willingness to act by providing opportunities for environmental identity work. At a broader level, systematic review in W13 of secondary-school environmental-literacy pedagogy reported a shift toward collaborative, critical, and active learning, while also identifying continued weakness in the development of environmentally responsible behavior. W14 similarly emphasized climate-change education that combines awareness with global competence and action.

Table 5: Determinants Of Environmental Literacy And Educational Approaches That Strengthen Environmental Action

Factor and approach	Main elements	Article codes
Knowledge-related factors	Environmental knowledge, species knowledge, science literacy, climate knowledge efficacy, recycling information	W4, W5, S5, S7, S14, S15, S16, E9, E12
Psychological factors	Attitudes, environmental concern, interest, enjoyment, identity, motivation, agency, self-efficacy	W6, W7, W8, S1, E9, E10, E12
Social factors	Gender, grade, study stream, socioeconomic background, subjective norms, peer and family influences	W1, W5, S2, S5, S12
Organizational factors	Environmental-education policy, eco-school status, sustainable leadership, pluralistic communication, democratic decision-making, school resources	W1, S2, E7
Experiential and nature-based learning	Outdoor learning, living-organism encounters, local place experiences, watershed work, nature activities	W6, W7, W8, E4, G5

Factor and approach	Main elements	Article codes
Socio-scientific learning	Inquiry-based climate learning, issue investigation, data analysis, identity-oriented exhibitions, problem-oriented learning	S1, S17, G5, G9
Citizen science participation	Coastal monitoring, biodiversity citizen science, service learning, community action, environmental citizenship	W11, E2, E3, E4, E5, E11, G6, G7
Curriculum targeted Environmental Education	Environmental science courses, Environmental Education kits, climate-change education, science-syllabus interventions, waste and water education	W14, S10, S11, E10, G3, G4

Overall, the 55-study narrative synthesis indicates that secondary school students' environmental literacy is best understood as a progression from knowledge and affect toward competence, agency, and situated behavior. Environmental knowledge and positive attitudes provide an important foundation, but they are insufficient when students lack efficacy, social support, authentic participation, or opportunities to practice environmental action. The strongest direction emerging from the reviewed literature is therefore the integration of knowledge-rich environmental education with inquiry, experiential learning, nature contact, democratic participation, citizen science, and action-oriented pedagogy. This integrated approach is particularly important if environmental education is expected to produce not only environmentally aware students, but environmentally competent young citizens capable of sustained private and collective action.

Discussion

The present narrative review examined environmental literacy and pro-environmental behavior among secondary school students through four interconnected dimensions: environmental knowledge, environmental attitudes, action competence, and behavioral practices. The findings indicate that environmental literacy among secondary school students should acquire environmental knowledge and understanding, develop affective orientations toward environmental issues, build the competence and confidence required to respond to these issues, and ultimately translate these capacities into individual or collective environmental action. Environmental knowledge provides an important cognitive foundation for environmental literacy. The reviewed studies examined knowledge relating to ecosystems, biodiversity, species, climate change, waste management, water conservation, energy use, and other environmental issues (W4, W5, W12, W14, S5, S7, S10, S14, E12, G3, G4). However, the findings show considerable variation in students' environmental knowledge. Wardani et al. (2018) and Prasetyo et al. (2020), for example, found that students did not demonstrate equally strong performance across environmental-literacy dimensions, particularly when environmental problems required analysis rather than factual recall (S3, S4). In contrast, studies focusing on familiar environmental issues, such as biodiversity and waste management, reported stronger student knowledge in particular domains (S5, S14). These findings suggest that environmental knowledge is often context-specific and may be influenced by students' direct experience with particular environmental issues.

The relationship between specific ecological knowledge and broader environmental literacy is also noteworthy. Härtel et al. (2023) showed that species knowledge was associated with environmental system knowledge and attitudes toward the environment (W4). This suggests

that knowledge about concrete organisms or ecosystems may provide an accessible pathway through which students develop a broader understanding of ecological relationships. Similarly, environmental knowledge related to climate change, energy, and resource use may strengthen students' ability to interpret environmental problems when the content is connected with observable and meaningful situations. Environmental education should therefore provide both conceptual knowledge and opportunities to apply this knowledge to real environmental contexts.

Environmental attitudes represent another prominent dimension of environmental literacy. The reviewed studies generally indicate that secondary school students express concern about environmental degradation and relatively positive attitudes toward environmental protection, biodiversity conservation, climate issues, and sustainable resource use (W4, S5, E9, E11, G10). However, positive environmental attitudes were not consistently accompanied by equally strong environmental skills or behaviors. This pattern was particularly evident in studies in which students expressed concern for environmental issues but demonstrated weaker issue-analysis competence, inconsistent behavioral practices, or limited participation in environmental action (S2, S4).

This discrepancy supports the widely observed gaps in environmental education. Possessing knowledge about an environmental problem does not necessarily result in behavioral change, and expressing a favorable environmental attitude does not automatically lead students to adopt environmentally responsible practices. Liao & Li (2019), for example, found that environmental knowledge contributed to students' intention to separate solid waste, but social influences such as subjective norms also played an important role (W5). Similarly, Aruta (2023) demonstrated that science literacy was related to energy-conservation behavior through climate-change knowledge efficacy (E12). These findings indicate that students may need more than environmental information. They also need confidence that their actions are effective, supportive social environments, and realistic opportunities to act.

This observation helps explain why action competence is particularly important in environmental and sustainability education. Action competence differs from simply performing prescribed environmentally friendly behaviors. Chen & Liu (2020) and Sass et al. (2020) conceptualized action competence as involving environmental understanding, willingness to act, confidence, decision-making ability, strategic thinking, and the capacity to participate meaningfully in environmental change (W15, W16). In this perspective, students should not merely be instructed to recycle, conserve energy, or reduce waste. They should understand why environmental action is necessary, evaluate alternative responses, decide how they wish to participate, and reflect on the potential consequences of their actions.

The importance of real opportunities for participation is supported by several reviewed studies. Torsdottir et al. (2024) found that students' experiences of influencing societal issues were positively associated with their perceived action competence, although such experiences were relatively uncommon in school settings (W3). Verhelst et al. (2022) also showed that sustainable leadership, pluralistic communication, organizational adaptability, and democratic decision-making within schools were associated with important dimensions of student action competence (E7). Together, these findings indicate that environmental education should move beyond classroom knowledge transmission toward school cultures in which students are able to discuss environmental controversies, participate in decision-making, design environmental initiatives, and experience the consequences of collective action.

The reviewed literature further demonstrates that pro-environmental behavior is not a single, uniform construct. Environmental behaviors varied according to environmental domain and educational context. Recycling and waste separation were frequently examined behaviors (W5, S14, S16), whereas other studies addressed energy conservation (S1, E12), biodiversity protection (W4, W6, W11), water conservation (G4), nature-related activities (W7, W8), environmental citizenship (E2), citizen science (E11), and civic or community participation (E5). Therefore, students who demonstrate environmentally responsible behavior in one domain may not necessarily behave similarly in another.

The distinction between private-sphere and public or collective pro-environmental behavior is especially important. Much previous environmental-literacy research emphasizes private actions such as recycling, saving energy, reducing waste, or conserving water. These behaviors are important but provide only one aspect of environmentally responsible citizenship. More recent studies have increasingly considered citizen science, service learning, environmental citizenship, community participation, and students' attempts to influence environmental decision-making (W3, W11, E1, E2, E3, E4, E5, E7, E11). This represents an important development because contemporary environmental problems such as climate change and biodiversity loss cannot be addressed through household behavior alone. Environmental education should therefore support both personal responsibility and students' capacity to participate in collective environmental change.

Another important finding concerns the role of nature experience and emotional connection with the natural world. Bezeljak et al. (2023) found that time outdoors and positive emotions toward nature were associated with students' connectedness with nature (W8), while Neurohr et al. (2024) linked interest in nature and participation in nature-related activities with self-reported pro-environmental behavior (W7). These findings suggest that environmental literacy is not exclusively cognitive. Direct contact with ecosystems, species, and local environments may strengthen environmental interest, emotional attachment, and personal relevance, which can subsequently support environmentally responsible behavior.

This interpretation is consistent with studies involving experiential and place-based environmental education. Sieg & Dreesmann (2021), for example, used direct encounters with living bumblebees to connect biodiversity knowledge, interest, environmental attitudes, and behavioral intentions (W6). Harris et al. (2023) showed that repeated outdoor interactions with a local organism contributed to urban adolescents' ecological sense of place (E4). Similarly, Marcum-Dietrich et al. (2021) used watershed-related data and technology to connect environmental learning with local environmental action (G5). These approaches reduce the distance between abstract environmental knowledge, and the places students experience in everyday life.

However, experiential education does not guarantee sustained behavioral change. Sieg & Dreesmann (2021) reported improvements in pro-environmental behavioral intentions following an educational intervention, but the effect was not sustained at follow-up (W6). Similarly, Kellberg et al. (2023) identified increased willingness to act following an identity-oriented socio-scientific intervention concerning the energy transition (S1). These findings suggest that short-term educational interventions may successfully generate interest or intention but may be insufficient to produce durable changes in behavior. Therefore, repeated engagement may be necessary. Students require continued opportunities to practise environmental behaviors, participate in meaningful environmental projects, reflect on their

experiences, and observe the consequences of their actions. Environmental behavior is likely to be more sustainable when environmental action becomes embedded within students' everyday school experiences.

School structures and institutional contexts also influence students' environmental literacy. Mónus (2022) demonstrated that school environmental-education policy and students' socioeconomic backgrounds were related to environmental attitudes and pro-environmental behavior (W1). Nurwidodo et al. (2020) found differences across environmental-literacy dimensions in the context of an Eco-School programme (S2), while Verhelst et al. (2022) emphasized the importance of organizational characteristics of schools (E7). These studies suggest that environmental literacy is not simply an individual student outcome. It is partly produced by school culture, curriculum, leadership, environmental policies, opportunities for participation, and the social context surrounding environmental action.

Demographic differences were also identified, although these relationships were not completely consistent across studies. Gender differences appeared in several studies, with female students frequently reporting stronger environmental attitudes, literacy, or knowledge (S1, S5, S12). Grade, study stream, and school type were also associated with differences in environmental-literacy dimensions (S1, S2, W1). However, demographic characteristics should not be interpreted as deterministic explanations of environmental behavior. Instead, they may indicate differences in educational experience, social expectations, environmental exposure, or opportunities to participate in environmental activities.

The findings further indicate that environmental education is becoming increasingly diverse in pedagogical approach. Traditional curriculum-based environmental education continues to contribute to students' knowledge and awareness, but recent research emphasizes experiential learning, inquiry-based learning, socio-scientific issues, citizen science, service learning, outdoor education, place-based education, and democratic participation. Brumann et al. (2022), for example, developed inquiry-based climate-change education for upper-secondary students (S17), while Araújo et al. (2023) demonstrated the educational potential of a coastal citizen-science project (E11). Schneller et al. (2022) connected environmental learning with service learning and ecojustice (E5), and López-Fernández et al. (2024) used responsible consumption experiences to engage students with sustainability issues (E3).

These approaches share several characteristics. They make environmental problems authentic rather than hypothetical, provide opportunities for investigation and decision-making, encourage students to interact with other people or communities, and allow students to experience themselves as participants rather than passive recipients of environmental knowledge. Specifically, experiential learning enables students to apply environmental concepts through problem solving and reflection, while outdoor education connects abstract knowledge with first-hand experiences of natural environments. Citizen science engages students in authentic environmental inquiry and data collection, and service learning connects environmental learning with community needs through practical projects. Therefore, one of the major patterns emerging from this narrative review is that environmental education appears most promising when environmental knowledge is integrated with experience, reflection, participation, and action, thereby helping students develop practical skills and action competence and bridge the gap between knowing and doing.

Conclusion

This study explored environmental literacy and pro-environmental behavior among secondary school students through a narrative review of 55 studies retrieved from Web of Science, Scopus, ERIC, and Google Scholar. Based on the narrative analysis, environmental literacy was examined through four interconnected components: environmental knowledge, environmental attitudes, action competence, and pro-environmental behavioral practices. The review also explored the individual, social, contextual, and educational factors associated with these outcomes and identified educational approaches that may strengthen students' environmental literacy and environmental action.

The reviewed literature indicates that environmental knowledge and environmental attitudes are the most extensively investigated components of environmental literacy. Secondary school students generally demonstrate awareness of environmental problems and relatively positive environmental attitudes. Nevertheless, levels of environmental knowledge vary across ecological topics and educational contexts, and favorable attitudes do not necessarily translate into environmentally responsible behavior. Consequently, environmental literacy should not be evaluated solely according to what students know or how positively they report feeling about environmental protection.

Action competence emerged as an important link between environmental learning and environmental behavior. Students need opportunities to develop not only environmental understanding but also willingness, self-efficacy, decision-making ability, strategic thinking, and experience in taking environmental action. The findings therefore suggest that environmental education should progress from knowledge-focused instruction toward approaches that enable students to investigate environmental problems, evaluate possible solutions, participate in decision-making, and experience meaningful environmental action.

Pro-environmental behavioral practices identified across the reviewed literature include recycling and waste separation, energy and water conservation, biodiversity protection, responsible consumption, nature-related activities, citizen science, civic engagement, and community environmental action. However, much existing research concentrates on self-reported individual behavior or behavioral intention. Collective environmental behavior and sustained action are less frequently investigated. Future environmental education research should therefore pay greater attention to long-term behavioral change, collective action, environmental citizenship, and students' participation in addressing real environmental problems.

The review further demonstrates that students' environmental literacy is influenced by multiple factors, including environmental knowledge, attitudes, interest, identity, self-efficacy, subjective norms, nature connectedness, demographic background, school environmental policies, school organizational characteristics, and educational experiences. No single factor can sufficiently explain environmental behavior. Environmental literacy and PEB should therefore be understood through a multidimensional and contextual perspective.

Educational approaches such as inquiry-based learning, outdoor and nature-based education, place-based learning, citizen science, service learning, socio-scientific learning, Eco-School initiatives, and targeted environmental education interventions show considerable potential for strengthening environmental literacy. Their common advantage is that they connect

environmental concepts with authentic problems, direct experience, social participation, and opportunities for action. Schools should therefore integrate environmental education across curriculum, co-curricular activities, institutional practices, and student participation rather than treating sustainability as an isolated subject or occasional educational activity.

This review may benefit environmental educators, school leaders, curriculum developers, researchers, and policymakers by clarifying the major dimensions of environmental literacy and identifying the conditions that support pro-environmental behavior among secondary school students. Future research should employ more longitudinal and intervention-based designs, use stronger measures of actual environmental behavior, examine action competence more explicitly, and investigate environmental literacy across diverse cultural and socioeconomic contexts.

In conclusion, the development of environmentally literate secondary school students requires more than the transmission of environmental knowledge. Effective environmental education should help students understand environmental problems, develop positive environmental values, build the competence and confidence to respond, and participate in meaningful individual and collective environmental action. By connecting knowledge, attitudes, action competence, and behavioral practices, schools may better prepare young people to respond actively and responsibly to contemporary environmental challenges.

-
- Acknowledgements:** The authors would like to express their sincere gratitude to Universiti Malaya Faculty of Education Department of Educational Foundations and Humanities for providing the necessary resources and support throughout the course of this research. Special appreciation is extended to colleagues and peers who contributed valuable insights and constructive feedback, which greatly enhanced the quality of this paper.
- Funding Statement:** No Funding
- Conflict of Interest Statement:** The authors declare that there is no conflict of interest regarding the publication of this paper. All authors have contributed to this work and approved the final version of the manuscript for submission to the International Journal of Modern Education (IJMOE).
- Ethics Statement:** This study did not involve any human participants, animals, or sensitive data requiring ethical approval. The authors confirm that the research was conducted in accordance with accepted academic integrity and ethical publishing standards.
- Author Contribution Statement:** All authors contributed significantly to the development of this manuscript. Author S.Y. was responsible for literature review, drafting, analysis, and interpretation of results. M.I.R. was responsible for critical revision of the manuscript the conceptualization and methodology. A.R.Z. contributed to academic support, constructive feedback, and overall supervision of the study. All authors read and approved the final version of the manuscript prior to submission.
- Declaration on the Use of Artificial Intelligence (AI)** The author(s) declare that no generative artificial intelligence (AI) or AI-assisted technologies were used in the preparation, writing, analysis, or revision of this manuscript.
-

References

- Abd Hamid, I., Yahaya, W. A. W., & Rahim, H. (2021). Assessment of awareness and behaviour among secondary school students on climate change. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 6(6), 259–264.
- Abd Wahab, A., & Mapa, M. T. (2021). Profil literasi alam sekitar mengikut faktor demografi pelajar sekolah menengah di Tawau, Sabah: environmental literacy profile according to factors among secondary school students in Tawau, Sabah. *Jurnal Kinabalu*, 27, 1–19.
- Akçay, S., & Şengül, H. (2023). A study on environmental literacy of middle school students. *Ahmet Keleşoğlu Eğitim Fakültesi Dergisi*, 5(1), 139–169.
- Amahmid, O., El Guamri, Y., Yazidi, M., Razoki, B., Kaid Rassou, K., Rakibi, Y., Knini, G., & El Ouardi, T. (2019). Water education in school curricula: Impact on children knowledge, attitudes and behaviours towards water use. *International Research in Geographical and Environmental Education*, 28(3), 178–193. <https://doi.org/10.1080/10382046.2018.1513446>
- Araújo, J. L., Morais, C., & Paiva, J. C. (2023). Students' attitudes towards the environment and marine litter in the context of a coastal water quality educational citizen science project. *Australian Journal of Environmental Education*, 39(4), 522–535.
- Arı, E., & Yılmaz, V. (2017). Effects of environmental illiteracy and environmental awareness among middle school students on environmental behavior. *Environment, Development and Sustainability*, 19(5), 1779–1793. <https://doi.org/10.1007/s10668-016-9826-3>
- Aruta, J. J. B. R. (2023). Science literacy promotes energy conservation behaviors in Filipino youth via climate change knowledge efficacy: Evidence from PISA 2018. *Australian Journal of Environmental Education*, 39(1), 55–66.
- Aydin, E., Selvi, M., Ince Aka, E., & Sarikaya, M. (2022). Determining Secondary School Students' Knowledge Levels on Ecosystem, Biodiversity, and Environmental Problems. *Educational Policy Analysis and Strategic Research*, 17(3), 82–101.
- Aydin, M., Degirmenci, T., Gurdal, T., & Yavuz, H. (2023). The role of green innovation in achieving environmental sustainability in European Union countries: Testing the environmental Kuznets curve hypothesis. *Gondwana Research*, 118, 105–116.
- Bayati, I. (2023). Students' perceptions of the natural world and their attitudes toward ecological issues: What is the relationship between them? *Australian Journal of Environmental Education*, 39(4), 536–549.
- Bezelsjak, P., Torkar, G., & Möller, A. (2023). Understanding Austrian middle school students' connectedness with nature. *The Journal of Environmental Education*, 54(3), 181–198. <https://doi.org/10.1080/00958964.2023.2188577>
- Brumann, S., Ohl, U., & Schulz, J. (2022). Inquiry-based learning on climate change in upper secondary education: A design-based approach. *Sustainability*, 14(6), 3544.
- Cahyani, R. P., Rahmat, A., Hamdiyati, Y., Amprasto, A., & Jamil, M. W. (2025). Does environmental knowledge predict attitudes and behaviors in environmental literacy? Evidence from senior high school students. *Journal of Biological Education Indonesia (Jurnal Pendidikan Biologi Indonesia)*, 11(3), 828–840.
- Chao, Y.-L. (2024). Different tracks, same greenness? Environmental literacy models integrated with teachers' environmental education practices for academic vs. technical/vocational high school students. *Cogent Education*, 11(1), 2357922. <https://doi.org/10.1080/2331186X.2024.2357922>
- Chen, S.-Y., & Liu, S.-Y. (2020). Developing students' action competence for a sustainable future: A review of educational research. *Sustainability*, 12(4), 1374.

- Covitt, B. A., Parker, J. M., Kohn, C., Lee, M., Lin, Q., & Anderson, C. W. (2021). Understanding and responding to challenges students face when engaging in carbon cycle pool-and-flux reasoning. *The Journal of Environmental Education*, 52(2), 98–117. <https://doi.org/10.1080/00958964.2020.1847882>
- Crea-Arsenio, M., Newbold, K. B., Baumann, A., & Walton-Roberts, M. (2022). Immigrant employment integration in Canada: A narrative review. *Canadian Ethnic Studies*, 54(2), 99–117.
- Dela Peña, P. N., Macale, A. M., & Largo, N. N. (2019). Environmental awareness and pro-environmental behaviors of high school students in Los Baños, Laguna. *Journal of Nature Studies*, 17(1), 56–67.
- Denault, A.-S., Bouchard, M., Proulx, J., Poulin, F., Dupéré, V., Archambault, I., & Lavoie, M. D. (2024). Predictors of pro-environmental behaviors in adolescence: A scoping review. *Sustainability*, 16(13), 5383.
- Duggan, G. L., Jarre, A., & Murray, G. (2021). Learning for change: Integrated teaching modules and situated learning for marine social-ecological systems change. *The Journal of Environmental Education*, 52(2), 118–132. <https://doi.org/10.1080/00958964.2020.1852524>
- El Batri, B., Alami, A., Zaki, M., Nafidi, Y., & Chenfour, D. (2019). Promotion of the environmental knowledge and behavior through the Moroccan syllabus of sciences in the middle school. *International Electronic Journal of Elementary Education*, 11(4), 371–381.
- Eze, E. (2020). Sociographic analysis of climate change awareness and pro-environmental behaviour of secondary school teachers and students in Nsukka Local Government Area of Enugu State, Nigeria. *International Research in Geographical and Environmental Education*, 29(1), 89–105. <https://doi.org/10.1080/10382046.2019.1657683>
- Ferrari, R. (2015). Writing narrative style literature reviews. *Medical Writing*, 24(4), 230–235. <https://doi.org/10.1179/2047480615Z.000000000329>
- Frensley, B. T., Stern, M. J., Powell, R. B., & Sorice, M. G. (2022). Investigating the relationships among students basic psychological needs, engagement, and environmental literacy at a residential environmental education center. *The Journal of Environmental Education*, 53(4), 186–198. <https://doi.org/10.1080/00958964.2022.2081654>
- Ganatsa, M., Tsakalimi, M., & Ganatsas, P. (2021). Factors affecting attitudes and behavior of Greek secondary school students on current environmental issues. *Review of International Geographical Education Online*, 11(3). https://dergipark.org.tr/en/pub/rigeo/article/860160?issue_id=62295
- Gibson, L., Stevenson, K., Busch, K. C., Cutts, B., Seekamp, E., & Kremetz, S. (2024). Pushing toward systemic change in the Capitalocene: Investigating the efficacy of existing behavior prediction models on individual and collective pro-environmental actions in high school students. *The Journal of Environmental Education*, 55(2), 102–124. <https://doi.org/10.1080/00958964.2023.2259853>
- Gladwin, D., Karsgaard, C., & Shultz, L. (2022). Collaborative learning on energy justice: International youth perspectives on energy literacy and climate justice. *The Journal of Environmental Education*, 53(5), 251–260. <https://doi.org/10.1080/00958964.2022.2113019>
- Guerrero, G., & Sjöström, J. (2025). Critical scientific and environmental literacies: A systematic and critical review. *Studies in Science Education*, 61(1), 41–87. <https://doi.org/10.1080/03057267.2024.2344988>

- Harris, C. B., Oliveira, A. W., Levy, B. L. M., Berkowitz, A. R., & Bowser, C. (2023). The eel connection: Developing urban adolescents' sense of place through outdoor interactions with a local organism. *The Journal of Environmental Education*, 54(4), 241–264. <https://doi.org/10.1080/00958964.2023.2216160>
- Härtel, T., Randler, C., & Baur, A. (2023). Using species knowledge to promote pro-environmental attitudes? The association among species knowledge, environmental system knowledge and attitude towards the environment in secondary school students. *Animals*, 13(6), 972.
- Hermawan, I., Suwono, H., Paranit, A. A. I., & Wimuttipanya, J. (2022). Student's Environmental Literacy: An Educational Program Reflections for a Sustainable Environment. *Journal of Biological Education Indonesia (Jurnal Pendidikan Biologi Indonesia)*, 8(1), 1–9.
- Huang, X., Erduran, S., Luo, K., Zhang, P., & Zheng, M. (2022). Investigating in-service teachers' STEM literacy: The role of subject background and gender. *Research in Science & Technological Education*, 1–21. <https://doi.org/10.1080/02635143.2022.2153243>
- Huoponen, A. (2024). How eco-clubs foster pro-environmental behavior in a school context: A case from Finland. *Fennia-International Journal of Geography*, 202(2), 227–246.
- Huoponen, A. (2025). *Pathways toward pro-environmental education: Synthesis of three voices from the school context* [PhD Thesis, Itä-Suomen yliopisto]. <https://erepo.uef.fi/bitstreams/641c42e7-b565-46ba-9c74-fae6cc8a9782/download>
- Kabylbek, K., DeChano-Cook, L. M., Childibaev, D., & Balta, N. (2025). Determining high school students' functional environmental literacy and the effect of participatory action research on functional environmental literacy. *Environmental Education Research*, 31(6), 1207–1223. <https://doi.org/10.1080/13504622.2024.2437572>
- Kellberg, S., Nordine, J., Keller, M., & Lewalter, D. (2023). Fostering students' willingness to act pro-environmentally through an identity-oriented socio-scientific exhibition on the energy transition. *Frontiers in Education*, 8, 1081633. <https://www.frontiersin.org/journals/education/articles/10.3389/feduc.2023.1081633/full>
- Khairani, A. Z., Kipli, M., & Shamsuddin, H. (2020). High school students' knowledge and its influence on attitude towards biodiversity at waterfront cities in Malaysia. *Universal Journal of Educational Research*, 8(1), 83–88.
- Leckey, E. H., Littrell, M. K., Okochi, C., González-Bascó, I., Gold, A., & Rosales-Collins, S. (2021). Exploring local environmental change through filmmaking: The Lentos en Cambio Climático program. *The Journal of Environmental Education*, 52(4), 207–222. <https://doi.org/10.1080/00958964.2021.1949570>
- Liao, C., & Li, H. (2019). Environmental education, knowledge, and high school students' intention toward separation of solid waste on campus. *International Journal of Environmental Research and Public Health*, 16(9), 1659.
- List, M. K., Schmidt, F. T., Mundt, D., & Föste-Eggers, D. (2020). Still green at fifteen? Investigating environmental awareness of the PISA 2015 population: Cross-national differences and correlates. *Sustainability*, 12(7), 2985.
- López-Fernández, C., Paños, E., & Ruiz-Gallardo, J.-R. (2024). Responsible consumers are made, not born: A clothing secondhand market experience in two Spanish high schools. *The Journal of Environmental Education*, 55(3), 203–222. <https://doi.org/10.1080/00958964.2023.2300447>

- Mahayuddin, S. A., Ishak, N. R., & Wan Zaharuddin, W. A. Z. (2024). Assessing the level of knowledge and practices of waste management among secondary school students. *Malaysian Journal of Sustainable Environment (MySE)*, 11(2), 281–296.
- Marcum-Dietrich, N., Kerlin, S., Hendrix, A., Sorhagen, N., Staudt, C., & Krauss, Z. (2021). Model my watershed: An investigation into the role of big data, technology, and models in promoting student interest in watershed action. *The Journal of Environmental Education*, 52(6), 384–397. <https://doi.org/10.1080/00958964.2021.1979451>
- Masson, T., Siebert, J., Köhler, S., Fritsche, I., & Zabel, J. (2025). Citizen Science Goes to School: Intervention Effects on Biodiversity Knowledge, Nature Relatedness, and Biodiversity Action in Secondary School Students. *Environment and Behavior*, 57(5–6), 359–398. <https://doi.org/10.1177/00139165251345383>
- Mgaiwa, S. J. (2021). Fostering Graduate Employability: Rethinking Tanzania's University Practices. *Sage Open*, 11(2), 21582440211006709. <https://doi.org/10.1177/21582440211006709>
- Mongar, K. (2023). The impacts of environmental science on Bhutanese students' environmental sustainability competences. *Australian Journal of Environmental Education*, 39(4), 437–451.
- Mónus, F. (2022). Environmental education policy of schools and socioeconomic background affect environmental attitudes and pro-environmental behavior of secondary school students. *Environmental Education Research*, 28(2), 169–196. <https://doi.org/10.1080/13504622.2021.2023106>
- Mustafaoğlu, F. M., & Alkan, F. (2025). Prediction of middle school students' recycling behaviors with machine learning algorithms. *Science Education International*, 36(2), 209–218.
- Neurohr, A.-L., Pasch, N., Bergmann-Gering, A., & Möller, A. (2024). Linking students' interest in nature to their self-reported pro-environmental behavior and nature activities – A cross-sectional study in grade 5 to 9. *The Journal of Environmental Education*, 55(6), 460–479. <https://doi.org/10.1080/00958964.2024.2364182>
- Nurwidodo, N., Amin, M., Ibrohim, I., & Sueb, S. (2020). The role of eco-school program (Adiwiyata) towards environmental literacy of high school students. *European Journal of Educational Research*, 9(3), 1089–1103.
- Olsson, D., Gericke, N., & Boeve-de Pauw, J. (2022). The effectiveness of education for sustainable development revisited – a longitudinal study on secondary students' action competence for sustainability. *Environmental Education Research*, 28(3), 405–429. <https://doi.org/10.1080/13504622.2022.2033170>
- Prasetyo, Irawati, M. H., Ibrohim, & Saptasari, M. (2020). Environmental literacy of high school students. *Journal of Physics: Conference Series*, 1567(4), 042076. <https://iopscience.iop.org/article/10.1088/1742-6596/1567/4/042076/meta>
- Qin, Z., Wu, Q., Bi, C., Deng, Y., & Hu, Q. (2024). The relationship between climate change anxiety and pro-environmental behavior in adolescents: The mediating role of future self-continuity and the moderating role of green self-efficacy. *BMC Psychology*, 12(1), 241. <https://doi.org/10.1186/s40359-024-01746-1>
- Radzi, S. N. F., Osman, K., & Mohd Said, M. N. (2022). Progressing towards global citizenship and a sustainable nation: Pillars of climate change education and actions. *Sustainability*, 14(9), 5163.
- Rahma, S., Solikha, M., & Mas' ud, A. (2026). Improving students' environmental literacy through a deep learning-based contextual teaching and learning model. *Journal of Educational Sciences*, ٢٧٨-٢٦٧), ٧(.

- Razak, S. A. A., Kamarudin, M. K. A., Toriman, M. E., Wahab, N. A., Saad, M. H. M., & Bati, M. (2019). Relationship between knowledge and attitudes towards environmental education among secondary school students in Malaysia. *International Journal of Academic Research in Business and Social Sciences*, 9(12), 37–49.
- Sass, W., Boeve-de Pauw, J., Olsson, D., Gericke, N., De Maeyer, S., & Van Petegem, P. (2020). Redefining action competence: The case of sustainable development. *The Journal of Environmental Education*, 51(4), 292–305. <https://doi.org/10.1080/00958964.2020.1765132>
- Schneller, A. J., Lacy, G., Kellogg, S., Pettigrew, S. M., Denny, C., Feldman-Schwartz, G., Beard, I., Rhodes, A., Wilson Radcliffe, B., Erickson, A., & Bardin, I. (2022). Urban ecojustice education: Transformative learning outcomes with high school service learners. *The Journal of Environmental Education*, 53(3), 127–140. <https://doi.org/10.1080/00958964.2022.2063784>
- Sieg, A.-K., & Dreesmann, D. (2021). Promoting pro-environmental behavior in school. Factors leading to eco-friendly student action. *Sustainability*, 13(12), 6598.
- Sony, M., Antony, J., & Douglas, J. A. (2020). Essential ingredients for the implementation of Quality 4.0: A narrative review of literature and future directions for research. *The Tqm Journal*, 32(4), 779–793.
- Susanti, W., & Nupus, D. H. (2022). Environmental Literacy Profile Analysis of Middle School Students in Science Learning. *Report of Biological Education*, 3(1), 11–16.
- Torsdottir, A. E., Olsson, D., & Sinnes, A. T. (2024). Developing action competence for sustainability—Do school experiences in influencing society matter? *Global Environmental Change*, 86, 102840.
- Troy Frensley, B., Stern, M. J., & Powell, R. B. (2020). Does student enthusiasm equal learning? The mismatch between observed and self-reported student engagement and environmental literacy outcomes in a residential setting. *The Journal of Environmental Education*, 51(6), 449–461. <https://doi.org/10.1080/00958964.2020.1727404>
- Van De Wetering, J., Leijten, P., Spitzer, J., & Thomaes, S. (2022). Does environmental education benefit environmental outcomes in children and adolescents? A meta-analysis. *Journal of Environmental Psychology*, 81, 101782.
- van Harskamp, M., Knippels, M.-C., & van Joolingen, W. (2024). Environmental Citizenship: Dutch students' sustainability competences and avenues for science education. *Journal of Environmental Education*, 55(4), 267–288.
- Verhelst, D., Vanhoof, J., De Maeyer, S., Sass, W., & Van Petegem, P. (2022). Enabling effective education for sustainable development: Investigating the connection between the school organization and students' action competence. *The Journal of Environmental Education*, 53(4), 171–185. <https://doi.org/10.1080/00958964.2022.2072797>
- Wandera, E., Andama, E., Atibuni, D. Z., & Suubi, U. M. S. (2022). *Environmental Literacy and Practice of Environmental Sustainability among Secondary School Students in Busia District, Eastern Uganda*. <https://nru.uncst.go.ug/items/ca5b8a2a-7811-47f1-ba7d-e91c2c363ac5>
- Wardani, R. A. K., Karyanto, P., & Ramli, M. (2018). Analysis of high school students' environmental literacy. *Journal of Physics: Conference Series*, 1022(1), 012057. <https://iopscience.iop.org/article/10.1088/1742-6596/1022/1/012057/meta>
- Xiong, Z., Song, Y., & Zhu, R. (2025). Pedagogical strategies for teaching environmental literacy in secondary school education: A systematic review. *Sustainability*, 17(20), 9104.

Yalçinkaya, E., & Çetin, O. (2018). An investigation of secondary school students' environmental attitudes and opinions about environmental education (EE). *Review of International Geographical Education Online*, 8(1), 125–148.