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From attitudes to action: a multidimensional model for sustainability education

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Despite the growing sustainability challenges faced globally, many individuals engage only minimally in daily sustainability efforts. Although access to information has become more convenient, many people do not actively seek out information on sustainability. However, understanding sustainability is central to continued engagement in sustainable practices. The European initiative NEB | Lab ECO²-Schools addresses this continued disengagement issue by approaching sustainability education more holistically. It integrates knowledge (information about sustainability), attitudes (a driving force for using this knowledge in sustainable engagement), and behaviors (actions to protect or preserve natural environments). Since health, defined as a person's physical, mental, and social wellbeing, is primary for almost any behavior, the initiative also integrates health promotion. This includes people's belief in their abilities, coping strategies, and resilience to handle ambiguity and complexity. This is particularly important in sustainability education, as many complex issues may only be solved eventually. Based on data from 794 participants and structural equation modeling, our findings support the foundational role of health promotion in shaping individuals' attitudes toward nature and environmental attitudes. Both attitudes, in turn, support learning about sustainability and engaging in sustainable behaviors. Researchers and educators may thus consider integrating health promotion with strengthening positive attitudes to support individuals' consistent, sustainable engagement.

KEYWORDS

environmental attitude, attitude toward nature, self-efficacy, outdoor experience, NEB | Lab ECO²-schools, sense of coherence, sustainability-related knowledge, ecological footprint

1 Introduction

Media presence, such as highlighting plastic pollution, along with public initiatives like the UN Sustainable Development Goals, contributes to raising awareness about sustainability issues. Those are underlined by curricular shifts toward embracing "green" issues and introducing more sustainability-related topics into classrooms, with schools being a critical infrastructure to lever sustainability in daily life. There is yet a lack of individual engagement despite the availability of information and the possibility of consumer and lifestyle choices. Several theoretical approaches offered ways to reduce this discrepancy, such as through values (DeGroot and Steg, 2008), norms (Harland et al., 1999), or attitudes (Bogner and Wiseman, 2006). With driving urgency, new initiatives are thriving. The European initiative NEB | Lab ECO²-Schools builds upon previous environmental education research, primarily focusing on knowledge and attitudes through a holistic approach (Eco² Schools, 2024). This approach originates from the GreenComp European sustainability competence framework, which serves as a reference tool for competencies related to sustainable living (Biachni et al., 2022). It

acknowledges health-promoting factors such as self-efficacy and resilience as a basis for sustainable efforts (Schutte and Bhullar, 2017). NEB | Lab ECO²-Schools integrates these competencies and involves students and staff in eco-renovating educational buildings while encouraging sustainable daily choices. In this way, it aims to improve sustainability education by connecting health-promoting competencies to sustainability-related knowledge, attitudes, and behaviors.

The EU initiative NEB | Lab ECO²-Schools eco-renovates educational buildings in five European countries through an Open Schooling concept, serving as learning hubs and role models for other buildings to follow (Eco² Schools, 2024). Open Schooling involves the users of the building (e.g., students and staff) and the community in an innovative eco-renovation process, enabling them to become active participants in addressing sustainability issues. Renovating buildings involves modernizing them to be resource-efficient, raising awareness, and engaging people effectively so they learn to use sustainability-related knowledge and competencies relevant to daily life. School renovations may include installing solar panels and intelligent lighting systems or starting a sustainable canteen. Students are actively engaged in the entire process. They participate in planning installations, learn about their technical and environmental aspects, utilize data from installations such as solar panels, and develop sustainable strategy plans for the green canteen (e.g., plastic waste management, reducing food waste, using locally sourced foods). They also benefit from these projects by using the energy generated from solar panels and consuming food from the canteen. Throughout the initiative, the students may better understand sustainability, learn about different behavioral options, and apply this knowledge to their daily choices, thus also outside of school (e.g., consuming low-waste locally grown foods and avoiding single-use plastics). They may also learn about the environmental impact of different energy sources and compare, for example, the costs and benefits of solar panels to other sources based on local conditions. The "whole school approach" by Mogren et al. (2019) is another example of how built environments can influence individual daily behaviors. Both approaches emphasize the importance of teaching beyond mere facts to promote a more sustainable lifestyle. This means that education should integrate understanding behavioral alternatives and the effectiveness of sustainable strategies (Frick et al., 2004). Ultimately, individuals need to be informed about sustainable practices so that they can effectively implement them.

NEB | Lab ECO²-Schools focuses on educational buildings at various stages, emphasizing the importance of education throughout life, including outreach facilities and science centers. In this regard, schools play a vital role in teaching sustainability, as they provide a foundational platform to reach many individuals, particularly at an age when attitudes and other internal variables are forming (Kaiser et al., 2014). Therefore, school students may be more receptive to change than adults. Sustainability education may continue at universities, expanding opportunities for students to develop competencies. Regardless of age, sustainable behaviors are likely based on people's wellbeing and resilience and, consequently, on health-supporting competencies such as adaptability (Schutte and Bhullar, 2017). These competencies—also subsumed under the term salutogenesis—are required for health maintenance and overcoming personal or societal challenges (Lindström and Eriksson, 2005). As a result, they are increasingly recognized in educational institutions, as acknowledged by the GreenComp framework.

The GreenComp framework provides a comprehensive set of sustainability competencies to support individuals in adopting more sustainable lifestyles, grounded in the principle of lifelong learning (Biachni et al., 2022). It integrates knowledge, skills, and attitudes in alignment with interdisciplinary approaches to environmental education (Kollmuss and Agyeman, 2002), acknowledging that factual knowledge alone is insufficient for sustained engagement (Bandura, 1982). The framework also emphasizes the importance of human health through coping strategies and problem-solving, leading to individual, collective, and political initiatives. Health promotion, in turn, may level knowledge, attitudes, and behavior. Within this framework, we assess the health-related competencies of (1) promoting nature, (2) critical thinking, (3) adaptability, and (4) individual initiative.

Promoting nature emphasizes the intrinsic connection between humans and the natural environment (Biachni et al., 2022). Recognizing the interdependence between humans and nature, including their needs, resilience, and health, is essential for promoting sustainable behavior. Positive experiences and direct contact with nature often strengthen this relationship, enhancing an individual's sense of connectedness to the natural world (Nisbet et al., 2008). Time spent outdoors, whether for restoration, recreation, education, or leisure, has been shown to deepen appreciation and emotional attachment to nature (Chawla, 1997; Tam, 2013), as reflected in one's attitude toward nature (Baierl et al., 2024). Attitude toward nature, in turn, may drive environmentally friendly behaviors (Whitburn et al., 2020). As such, increased exposure to natural environments tends to cultivate emotional bonds and empathy for all living beings, thereby making individuals more likely to engage in nature conservation and preservation (e.g., Hinds and Sparks, 2008; Mayer and Frantz, 2004).

Critical thinking is the ability to identify credible information, such as recognizing greenwashing, as well as to manage uncertainty, navigate complex scenarios, and, thereby, adapt to change (Sala et al., 2020). In a rapidly changing world that produces an overwhelming influx of knowledge, individuals must be equipped to critically evaluate information and arguments to draw sound conclusions and develop sensible solutions (Paul and Elder, 2002). This involves reflection on personal and others' viewpoints, an awareness of cultural contexts, and a willingness to confront one's own flaws and biases (Tversky and Kahneman, 2003), such as confirmation biases, suggesting that people prefer ideas that align with their beliefs and expectations (Nickerson, 1998). Cultivating critical thinking thus requires not only analytical skills but also intellectual humility and openness to diverse perspectives.

Along those lines, adaptability emphasizes coping with ambiguity, uncertainty, and risk. Those coping strategies develop continuously throughout life (Lindström and Eriksson, 2005); they are decisive for navigating the complexity of modern life and addressing sustainability challenges across economic, ecological, and societal domains. Both critical thinking and adaptability require recognizing that many sustainability issues may not have immediate solutions. Instead, these issues demand proactive engagement to prevent or mitigate long-term consequences and adapt human lifestyles and technologies accordingly. Critical thinking assists in managing complex, conflicting information and drawing conclusions, while adaptability allows for flexible responses to evolving, intricate circumstances. Together, these abilities foster responsible action in the face of environmental challenges, a capacity

closely linked to Antonovsky's (1996) concept of sense of coherence—the perception of life as understandable, manageable, and meaningful.

Individual initiative relies on recognizing achievable sustainability actions, having confidence in one's capability to accomplish them (i.e., locus of control and self-efficacy), and being willing to act (i.e., attitudes). Self-efficacy is the belief in achieving a desired outcome (Bandura and Wessels, 1994). It emanates from people's assessment of their capabilities and their perceived effectiveness, which, in turn, influences their attitudes and behaviors (Bandura, 1982). The more people perceive themselves as capable of carrying out an activity, the more likely and vigorously they will engage, regardless of the study area, such as sports (Weinberg et al., 1979), learned helplessness (Brown and Inouye, 1978), or health-related intentions and behaviors (Sheeran et al., 2016). Conversely, people avoid behaviors they consider beyond their capabilities (Bandura, 1982). Individual initiative involves actively contributing to sustainable development, relying on people's self-efficacy and attitudes—their motivational drive to act (Biachni et al., 2022).

An attitude is a motivational concept (Allport, 1933), a relatively persistent internal drive leading to a willingness for action (Biachni et al., 2022). In environmental education research, two distinct attitudes have become relevant for teaching and learning sustainability: attitude toward nature and environmental attitude (Kaiser et al., 2014). Attitude toward nature reflects people's propensity to appreciate and enjoy the natural environment, e.g., for recreational and restorative outdoor activities (Brügger et al., 2011; Tam, 2013). Environmental attitude, on the other hand, reflects people's propensity to minimize harm to nature and actively protect it, demonstrating their commitment to nature preservation and conservation (Baierl et al., 2022b). While both attitudes are decisive for environmental engagement (e.g., Dutcher et al., 2007), attitude toward nature appears to be a predecessor: Research indicates environmental attitude's mediating role between attitude toward nature on learning and ecological engagement (Baierl et al., 2024; Geng et al., 2015; Wells and Lekies, 2006). This is supported by the many positive correlations between attitude toward nature and knowledge or behavior scores (e.g., Bonnett and Williams, 1998; Whitburn et al., 2018) and typically stronger correlations between environmental attitude and knowledge or behavior scores (e.g., Davis et al., 2011; Thompson and Barton, 1994), rendering both attitudes relevant to learning and education. Attitude toward nature can be fostered by nature contact, spending time outdoors, and working with original objects (see, e.g., Dresner and Gill, 1994), which, in turn, may spur their environmental attitudes (Baierl et al., 2022a; Ewert et al., 2005).

Research goals

This study aims to investigate the role of health-promoting competencies—such as self-efficacy and sense of coherence—in shaping sustainability-related knowledge, attitudes, and behaviors, thereby contributing to the broader framework of sustainability education. Building on prior research that highlights the importance of attitudes in sustainable action (e.g., Baierl et al., 2022b; Baierl and Bogner, 2024), we explore how psychological resources that support wellbeing may reinforce educational efforts toward sustainable development.

I Validation of relationships: To what extent can established relationships among sustainability-related knowledge, attitudes, and behaviors be validated across three European cohorts, both collectively and individually?

II Influence of health-promoting competencies: How do competencies that support psychological wellbeing influence sustainability-related knowledge, attitudes, and behaviors, and the structural relationships among them?

III Educational implications: What initial recommendations for sustainability education can be derived from the observed relationships between health-promoting competencies and sustainability-related outcomes?

2 Materials and methods

2.1 Participants and procedure

Our study relied on a sample of 794 participants (M_{age} = 18.11, SD = 13.79) based on 54.53% (n = 433) females and 39.67% (n = 315) males; 46 (5.79%) study participants provided no information on gender. Most reported living in an urban area (n = 401), while only 107 lived in a rural area. We lack information on the living areas of 286 participants. Written informed consent was obtained from all participants for their anonymized data to be used in this study. For under aged students, consent was obtained from their parents or legal guardians. Ethical approval was obtained from the Cork University Ethics Committee (Log 2023–069) and waived for two subsamples as the data was anonymized, ensuring that participants could not be identified, and no sensitive data was collected. The research was conducted in an educational setting as part of regular lessons.

In Ireland, 184 university students completed the questionnaire (M_{age} = 25.14, SD = 9.52; 69.6% [n = 128] females and 26.6% [n = 49] males, while 3.8% [n = 7] preferred not to respond to gender). The majority of the students lived with their family (58.2%, n = 107), in a shared flat (22.8%, n = 42), or with their partner (13%, n = 24), so in company with others. 76.6% (n = 141) lived in a house and 19.6% (n = 36) in an apartment or flat. About two-thirds had pets (57.1%, n = 105), while 39.1% (n = 72) had no pets. The study participants were asked how often they talked about environmental issues at home. 3.3% (n = 6) talked never about environmental issues at home, 32.1% (n = 59) indicated talking every few weeks, 19% (n = 35) once per week, 26.6% (n = 49) talked two or three times per week about environmental issues, and 15.2% (n = 28) every day. The study participants were also asked how frequently they discussed science at home. 12.2% (n = 23) said they never talked about science at home, 23.4% (n = 43) talked every few weeks about science, 11.4% (n = 21) once per week, 29.3% (n = 54) talked two or three times per week about science, and 19.6% (n = 36) every day.

In Sweden, 142 school students (n = 116) and their teaching staff (n = 28) participated in the data collection (M_{age} = 21.29, SD = 9.41; 59.9% [n = 85] females and 35.2% [n = 50] males, 4.9% [n = 7] preferred not to respond to gender). Also, in this subsample, most lived with their families (60.6%, n = 86), in a shared flat (4.9%, n = 7), or with their partner (4.2%, n = 6), and 2.8% (n = 4) lived on their own. 73.2% (n = 124) lived in a house and 12.7% (n = 18) in an apartment or flat. About half of the sample had pets (55.6%, n = 79), while 43% (n = 61) did not. 13.4%

(n = 19) never talked about environmental issues at home, 42.3% (n = 60) talked once every few weeks, 21.1% (n = 30) indicated once per week, 18.3% (n = 26) talked two or three times per week, and 4.9% (n = 7) talked every day about environmental issues. When asked how often students discussed the science they learned at school at home, 19.7% (n = 28) indicated never talking about such topics, 33.1% (n = 47) talked once every few weeks about science, 12.7% (n = 18) once per week, 13.4% (n = 19) talked two or three times per week about science, and 10.6% (n = 15) every day.

In Greece, 468 school students completed the questionnaire (M_{age} = 13.78, SD = 1.05; 47% [n = 220] female and 46.2% [n = 216] male adolescents; 6.8% [n = 32] preferred not to respond to gender). Most of the students lived in an urban area (85.3% [n = 399]), and only 14.3% in a rural area (n = 67). Due to time restrictions in class for completing questionnaires, we only have additional demographic information on 333 students. About half of the sample lived in a house (52.3%, n = 174), and 47.7% lived in an apartment or flat (n = 159). Most of the school students did not share their room with anybody (80.2%, n = 267), and only 10.5% (n = 35) had pets in their room, 7.5% (n = 25) shared it with siblings, or with siblings and pets (1.8% [n = 6]). In this regard, about half of the sample had pets (55.9%, n = 186), while 44.1% (n = 147) did not. 24.6% (n = 82) never talked about environmental issues at home, 40.8% (n = 136) talked once every few weeks about such topics at home, 10.5% (n = 35) did so once per week, 19.2% (n = 64) talked two or three times per week, and 4.5% (n = 15) talked every day about environmental issues. 20.4% (n = 68) indicated they never talked about the science they learn at school in their homes. 42% (n = 140) talked once every few weeks about the science they learned, 11.7% (n = 39) once per week, 20.4% (n = 68) talked two or three times per week about the science they learned at school, and 4.5% (n = 15) every day.

2.2 Measures

All statistical analyses were conducted using IBM SPSS Statistics (Version 27), including descriptive statistics and correlation analyses. To examine latent constructs and structural relationships, we applied confirmatory factor analysis and structural equation modeling using IBM SPSS AMOS (Version 27). Model fit was evaluated using standard indices such as the Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA). For the calibration of attitudes and knowledge, we employed ConQuest software (Version 4.0) to perform Rasch modeling, enabling the evaluation of item fit and scale reliability.

We collected two sets of measurements at a single testing point for a comprehensive model in sustainability education. The first set focused on health-promoting factors, which included individuals' self-efficacy (assessed through their sense of internal control and self-concept regarding their abilities, a variation of the locus of control), sense of coherence, and outdoor experiences. The second set evaluated knowledge levels, attitudes toward nature, environmental attitudes, and the ecological footprint as a proxy for sustainable behavior. For a comprehensive overview of all constructs see Table 1. To ensure test fairness, we calibrated the scales for each country in preliminary analyses. As the measurements were consistent for each setting, we will provide the quality criteria for the entire sample (N = 794) to highlight overall trends while analyzing the sub-samples in further detail.

The comprehensive idea of health promotion and maintenance includes four constructs derived from the GreenComp framework (Biachni et al., 2022), acknowledging that health comprises physical, mental, and social wellbeing rather than the mere absence of disease (Antonovsky, 1996). The survey assessed the participants' sense of coherence (Rajesh et al., 2016), outdoor experiences, and self-efficacy (Anderson et al., 2005).

TABLE 1 This overview presents the constructs measured in our integrated multidimensional model for sustainability education.

Set of measurement	Construct	Constructs essentials	References
Health promotion	Sense of Coherence	A resilience-based framework describing an individual's capacity to perceive life as comprehensible, manageable, and meaningful, enabling effective coping with stress and adversity.	Rajesh et al. (2016)
	Self-efficacy	A person's belief in their ability to influence outcomes and handle challenges, assessed through their sense of personal control (internality) and confidence in their competence (self-concept).	Anderson et al. (2005)
	Outdoor experience	Outdoor experiences promote wellbeing by encouraging physical activity, emotional balance, and social interaction, both through solitary and shared time in nature.	Self-developed, original items
Common sustainability education measures	Environmental attitude	It reflects a person's propensity to avoid harming nature and to actively protect and preserve it.	Baierl et al. (2022b)
	Attitude toward nature	It represents an individual's propensity to appreciate, enjoy, or connect with nature and to utilize it for restoration or recreation.	Baierl et al. (2024)
	Sustainability-related knowledge	It conveys knowledge about sustainability issues and strategies to promote sustainability or reduce environmental harm.	Self-developed, original items
	Ecological footprint	It reflects the environmental impact of individual behaviors across domains like energy use, food, transport, and consumption.	Derived from the Global Footprint Network (2021)

Note: One set of constructs includes those commonly assessed in sustainability and environmental education, while the second set focuses on health promotion. The latter is considered preliminary to the other constructs, as a stable foundation in health-related fundamentals may allow for greater capacity to advance sustainability efforts. The reference includes literature where we utilized established items for our study. If no suitable, established item set was available, we developed original items for our research.

Antonovsky (1993) focused on factors that help cope with crises, rather than on risk and disease. He emphasized the importance of meaningfulness, adaptability, coping strategies, and perceived social support, which are dynamic and develop throughout one's lifetime (Lindström and Eriksson, 2005). The concept of *Sense of Coherence* (Antonovsky, 1996) is basic for health promotion and a resource for coping with challenges. The concept involves three elements: (1) meaningfulness, which refers to finding purpose in the world; (2) comprehensibility, which is one's belief in being able to understand challenges; and (3) manageability, which encompasses one's perception of having the necessary resources to cope with challenges (Antonovsky, 1996). We utilized seven items from Rajesh et al.'s (2016) scale, which was adapted for use with adolescents (see Figure A1). The study participants responded on a five-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). We employed Amos software (Arbuckle, 2016) to carry out a unidimensional, confirmatory factor analysis: Chi-square = 54.068 (14 df), $p < 0.001$, CMIN/DF = 3.862, CFI = 0.974, and RMSEA = 0.054.

Locus of Control and *Self-efficacy* were combined into a single scale by Anderson et al. (2005). The scale is based on Levenson's (1981) concept of the locus of control. Krampen (1991) adapted Levenson's (1981) scale to be less culturally dependent. Anderson et al. (2005) further enhanced this culturally flexible version by incorporating the self-concept, which refers to an individual's self-efficacy. We utilized 10 items to measure self-efficacy, reflected by the subscales of internality and self-concept. Participants responded to evaluative statements using a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Amos software (Arbuckle, 2016) was used for confirmatory factor analysis. The seven items of the internality scale indicated fair fit indices: Chi-square = 41.260 (14 df), $p < 0.001$, CMIN/DF = 2.947, CFI = 0.970, and RMSEA = 0.044 (Figure A2). We identified a person's self-concept using four items: Chi-square = 5.329 (2 df), $p = 0.070$, CMIN/DF = 2.665, CFI = 0.991, and RMSEA = 0.041 (Figure A3).

The survey asked participants about their *Outdoor experience* using seven items. Four items focused on individual experiences in nature, while three inquired about outdoor activities with others. One item asked about spending leisure time outdoors with friends, another inquired about hiking, nature walks, or picnics with their family, and a third asked about outdoor lessons, such as in the school garden (see Figure A4). For adults, questions about lessons were asked retrospectively. The participants rated their experiences on a five-point frequency scale ranging from 1 (never) to 5 (always). We used a one-dimensional factor analysis as a proxy of outdoor experiences (CMIN/DF = 2.486, CFI = 0.972, and RMSEA = 0.067).

Environmental attitude reflects an individual's propensity to minimize harm to nature and to actively protect it (Baierl et al., 2022b). We used 28 items from the pool of Baierl et al. (2022b), and the scale was calibrated using a dichotomous Rasch model (see Rasch, 1980). The person separation reliability (*rel.* = 0.80) indicates that the scale differentiated fairly well among the participants. Mean Square (MS) values reflect the discrepancy between the Rasch model's prediction and actual responses. A value of 1.10 indicates 10% more response variation than the model predicted. MS weighted by the item variance (MS_w) fell between 0.81 and 1.22, so they were within reasonable boundaries (Bond and Fox, 2007). Only one item was too heterogeneous in its responses ($MS_w = 1.34$): "If I am offered a plastic bag in a store, I take it." Some study participants with positive attitudes agreed on it, while others with negative attitudes did not. It is thus a poor proxy for environmental attitude with our cohort, probably given cultural differences in using plastic bags. Therefore, the item was excluded from further analysis. Person parameters ranged from −3.71 to 2.88 ($M = -0.09$ [$SD = 1.02$]). Item difficulties (i.e., the cost involved in carrying out a behavior) ranged from −1.13 to 1.74 ($M = 0.0$ [$SD = 0.63$]).

Attitude toward nature reflects a person's propensity to appreciate, enjoy, or connect with nature (see Baierl et al., 2024; Brügger et al., 2011). Indicator items include self-reports about nature bonding activities, such as "I take time to watch the clouds pass by," and responses to evaluative statements about nature appreciation, such as "I like the quiet of nature." We used 27 items from the item pool of Baierl et al. (2024). The person reliability score (*rel.* = 0.83) was good, and MS_w values fell within a reasonable range between 0.85 and 1.30 (see Bond and Fox, 2007). Person parameters ranged from −3.55 to 3.59 ($M = 0.17$; $SD = 1.22$). Item difficulties (i.e., the cost involved in a behavior) ranged from −1.45 to 1.92 ($M = 0.0$; $SD = 0.86$).

For both attitudes, the study participants responded to self-reported behaviors on five-point frequency scales ranging from 1 (never) to 5 (always) or a yes-no format, for which they could choose *not applicable* if they were indecisive, which was coded as a missing value. The study participants responded to evaluative statements on a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Six items were negatively formulated and reverse-coded before the analysis. All polytomous items were dichotomized for the Rasch calibration. Therefore, *never*, *seldom*, *occasionally*, *strongly disagree*, *disagree*, and *not sure/neutral* were coded as a lack of nature appreciation or preservation (= 0). *Often*, *always*, *agree*, and *strongly agree* were coded as an expression of nature appreciation or preservation (= 1).

Sustainability-related knowledge comprises system, action, and effectiveness knowledge (13 items in total), a common distinction of knowledge dimensions adopted from Frick et al. (2004). Those items were presented in a single-choice format with four options and one correct answer. System knowledge covers facts and an understanding of ecosystem functioning and sustainability issues. An example used in this study is "Which of the following is not a renewable energy?" with its four answer options: (1) solar energy, (2) fossil energy, (3) wind power, and (4) biomass. Action knowledge involves knowledge about different behaviors, for example, "How can you help remove carbon dioxide from the atmosphere?" with its four answer options: (1) plant trees, (2) ride a bicycle, (3) wear clothing made from natural fibers, and (4) use wood as fuel. This type of knowledge helps individuals put system knowledge into practice by showing them what they can do regularly. Effectiveness knowledge deals with understanding the impact of environmental strategies, such as comparing different initiatives for climate change mitigation. We used the Rasch model for calibration (see Adams and Khoo, 2015). Knowledge was measured in logits, so the more positive a logit value is, the stronger we assume an individual's environmental knowledge to be. Logits indicate the natural logarithm of the ratio between the relative frequencies of correct and incorrect responses and fell between −2.80 and 3.25 logits ($M = 0.41$, $SD = 1.63$). The separation reliability indicated that the scale accurately distinguished among the study participants (*rel.* = 0.74; $MS_w = 0.82–1.24$), and item difficulties ranged from −1.07 to 3.84 ($M = 0.00$; $SD = 1.23$).

Ecological footprint: We used items from typical footprint calculators and added a few on other consumption behaviors, such as second-hand shopping (Global Footprint Network, 2021). We chose those items that were within the scope of our cohort. We therefore excluded items related to housing and included items on age-related consumption behaviors. The items covered four domains: electricity, nourishment, transportation, and other consumption of goods such as clothes or resources spent on leisure. The study participants responded to 29 self-reported behaviors on five-point frequency scales ranging from 1 (never) to 5 (always). A total of 14 items were negatively formulated and reverse-coded before the analysis. We derived the mean score from those 29 items as a behavioral indicator, reflecting their level of pro-environmental engagement ($M = 2.95$, $SD = 0.38$).

3 Results

We first conducted Pearson correlations to examine the relationship between health-promoting factors, attitudes, knowledge, and the ecological footprint as a behavior indicator (see Table 2). Our findings are consistent with existing literature. For instance, environmental attitudes show a stronger correlation to pro-environmental behavior than knowledge levels do (e.g., Pooley and O'Connor, 2000). Then, we find the typical correlation between attitude toward nature and environmental attitude (e.g., Baldi et al., 2021; DeVille et al., 2021; Mackay and Schmitt, 2019), while the correlation between environmental attitude and knowledge levels is stronger than the correlation between attitude toward nature and knowledge (e.g., Baierl et al., 2024). We also find a significant positive correlation between internality and self-concept, indicating that both contribute to a person's self-efficacy within their locus of control (Anderson et al., 2005).

In the next step, we delved deeper into the relationships between the variables and worked toward creating an integrated sustainability model. Recent research suggested that environmental attitude may play a mediating role: While positive attitude toward nature levels influence the acquisition and retention of knowledge, environmental attitude seems to mediate this relationship (Baierl et al., 2024). We tested such a potential mediation and included an additional component: the impact of outdoor experiences, which positively contributes to attitudes toward nature (see Figure 1).

Having tested the suggested core of an integrated sustainability model, including the roles of attitudes and their positive effect on learning, we added health promotion variables (see Figure 2). These competencies, such as adaptability and individual initiative, encompass internality and self-concept, forming a person's self-efficacy (Anderson et al., 2005), and sense of coherence (Rajesh et al., 2016). To ensure test fairness, we conducted a group analysis in Amos (Arbuckle, 2016) to verify the results for the three subsamples (see Figures A5–A7 in the Supplementary Material). The trends are similar, with slight variations in their regression weights.

Figure 2 presents findings from the full sample, highlighting the significant impact of adaptability, individual initiative, and outdoor experiences—key components of health promotion—on core constructs commonly evaluated in sustainability and environmental education. These constructs include attitudes toward nature, environmental attitudes, sustainability-related knowledge, and the ecological footprint as a behavioral indicator. The data reveal that health-promoting factors exhibit stronger associations with attitudes toward nature (total sample: b = 0.35, Irish sample: b = 0.17, Swedish sample: b = 0.45, Greek sample: b = 0.38) than with environmental attitudes (total sample: b = 0.14, Irish sample: b = 0.12, Swedish sample: b = 0.22, Greek sample: b = 0.10) or knowledge scores (total sample: b = 0.23, Irish sample: b = 0.27, Swedish sample: b = 0.42, Greek sample: b = 0.17). It is

TABLE 2 Pearson correlations between the individual measurements within our integrated sustainability model.

Construct		Environmental attitude	Attitude toward nature	Internality	Self-concept	Sense of coherence	Outdoor experience	Ecological footprint
Knowledge	*r*	**0.456**	**0.411**	**0.383**	**0.371**	0.012	**0.168**	**0.262**
	p	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	*n.s.*	**< 0.001**	**< 0.001**
Environmental attitude	*r*		**0.624**	**0.389**	**0.376**	0.057	**0.259**	**0.314**
	p		**< 0.001**	**< 0.001**	**< 0.001**	*n.s.*	**< 0.001**	**< 0.001**
Attitude toward nature	*r*			**0.420**	**0.408**	**0.125**	**0.451**	**0.294**
	p			**< 0.001**	**< 0.001**	**0.001**	**< 0.001**	**< 0.001**
Internality	*r*				**0.973**	**0.204**	**0.224**	**0.097**
	p				**< 0.001**	**< 0.001**	**< 0.001**	**0.007**
Self-concept	*r*					**0.198**	**0.220**	**0.097**
	p					**< 0.001**	**< 0.001**	**0.007**
Sense of coherence	*r*						**0.146**	**0.119**
	p						**< 0.001**	**0.001**
Outdoor experience	*r*							**0.184**
	p							**< 0.001**

Note: health-promoting factors include internality and the self-concept (reflecting a person's self-efficacy; see Anderson et al., 2005), sense of coherence (Rajesh et al., 2016), and outdoor experiences.

Bold numbers indicate significant correlations. Environmental attitude (Baierl et al., 2022b), attitude toward nature (Baierl et al., 2024; Brügger et al., 2011), and sustainability-related knowledge are well-established variables in environmental education research. The ecological footprint, as defined by the Global Footprint Network (2021), serves as an indicator of sustainability efforts.

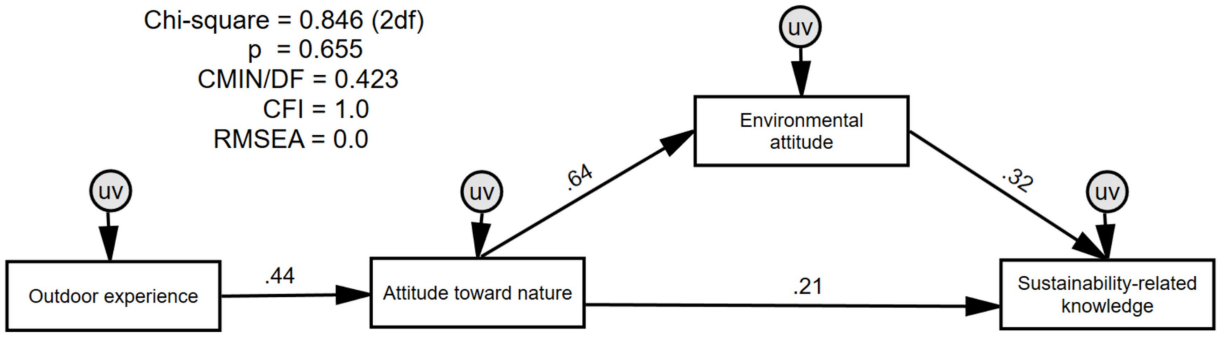

FIGURE 1
According to recent research, environmental attitude appears to mediate attitude toward nature's positive effect on knowledge scores (Baierl et al., 2024), which is replicated by our study (N = 794). We further examined the impact of outdoor experiences on attitudes toward nature. Spending time outdoors, whether alone, with others, or for educational purposes, was associated with higher attitude toward nature scores.

important to note that the significantly lower numbers for environmental attitudes may stem from a suppression effect, as attitudes toward nature could act as a mediator, explaining much of the variance.

Furthermore, attitudes toward nature positively influence environmental attitudes (b = 0.58), which in turn facilitate both the acquisition of sustainability knowledge (b = 0.36) and the enactment of sustainable behaviors (b = 0.26). Importantly, while health-promoting factors contribute to the development of attitudes and enhance learning potential, knowledge alone appears to exert minimal influence on sustainability related behaviors (b = 0.12). Instead, environmental attitudes emerge as the primary driver of such behaviors (b = 0.26). These findings underscore a dynamic interplay between health promotion, attitudes toward nature, and environmental attitudes, collectively shaping sustainability engagement.

These trends were consistent across all three national subgroups, with the most pronounced differences observed in knowledge scores. In the Irish cohort, higher levels of sustainability-related knowledge were significantly associated with increased sustainable behaviors (b = 0.26), a relationship not observed in the Swedish (b = 0.10) and Greek (b = 0.01) cohorts. Additionally, outdoor experiences consistently exerted a substantial influence on attitudes toward nature (Greek sample: b = 0.31, Swedish sample: b = 0.29, total sample: b = 0.35), with the strongest effect again noted in the Irish sample (b = 0.6). Overall, despite slight differences, the relationships are similar across the subgroups, so the data suggest a general pattern: individuals with stronger health-promoting competencies tend to exhibit more positive attitudes, which in turn increase the likelihood of learning about sustainability and engaging in sustainable behaviors.

4 Discussion

The Health-promoting competencies we applied, as assessed through the sense of coherence and self-efficacy, along with individuals' outdoor experiences, positively impact attitudes and, in turn, contribute to learning and sustainable engagement. We carefully tested an integrated sustainability model using samples from three European countries: Greece, Sweden, and Ireland. This allowed us to evaluate the fairness of tests at educational institutions across various age levels that are important for developing competencies related to sustainability.

At the core of the model (Figure 2) are knowledge (about sustainability and sustainability-related behaviors) and attitudes (attitude toward nature and environmental attitude), which positively affect sustainable behaviors (ecological footprint indicators). This key connection is based on health-promoting factors such as self-efficacy, suggesting that attitudes and sustainability-related knowledge require a solid foundation in health-maintaining factors for further sustainability competencies to flourish. The positive impact of several of these individual variables on their own has been reaffirmed over time (e.g., Hines et al., 1987; Van Valkengoed et al., 2022), and our data presents them in a single model, with health promotion as the foundation.

Our data supports the notion that knowledge about sustainability issues is important for sustainable efforts (see Table 1: r = 0.26; Figure 2: b = 0.12; see, also, Heimlich and Ardoin, 2008), especially if the knowledge covers individual behavioral options and the effectiveness of sustainable strategies (Frick et al., 2004), as it did in our study. However, literature states knowledge alone is not enough for sustained engagement (Kollmuss and Agyeman, 2002; Marcinkowski and Reid, 2019) and does not guarantee corresponding behavior (Barth et al., 2012). Along those lines, our findings show that the effect of environmental attitude on sustainable behaviors is stronger than the contributing role of knowledge (see Table 1: r = 0.31; Figure 2: b = 0.26). While knowledge about sustainability issues is relevant, people's attitudes appear more relevant for sustainable engagement (see also Miller et al., 2022).

Accordingly, a person's environmental attitude appears more powerful for engaging in sustainable behaviors and aids in acquiring and retaining sustainability-related knowledge (see, e.g., also Glasman and Albarracín, 2006; Marcinkowski and Reid, 2019). We can consider knowledge as a positively correlated but insufficient variable influencing sustainability-related behaviors (see also Heimlich and Ardoin, 2008). However, we can also regard a person's knowledge score as a consequence of positive attitudes (e.g., Baierl et al., 2022b; Henn et al., 2019): The more positive their attitude toward nature (i.e., their appreciation for natural environments) and their environmental attitude (i.e., their propensity to protect and

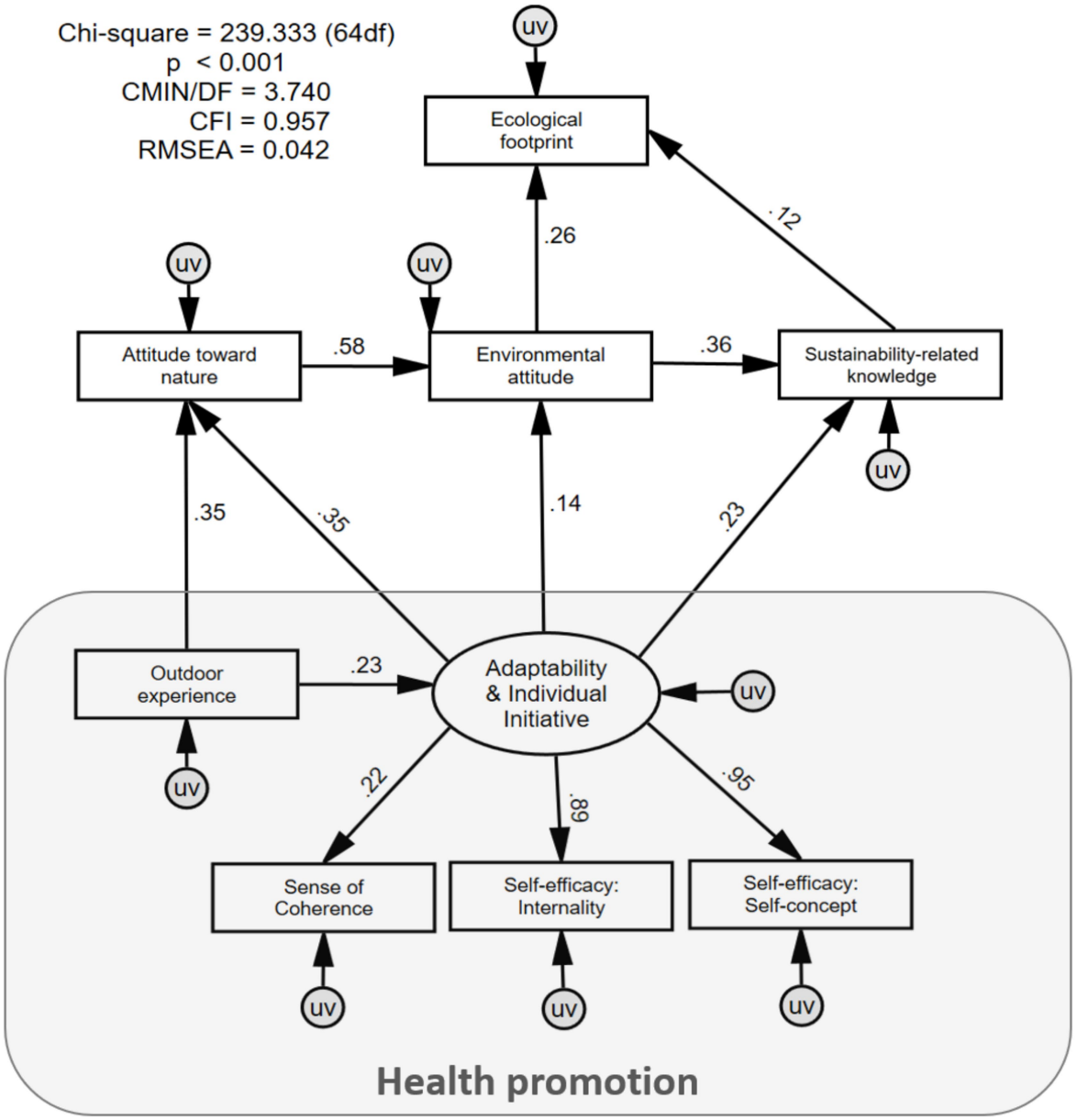

FIGURE 2
An integrated sustainability model (N = 794) with attitude toward nature and environmental attitude playing relevant roles in learning about sustainability and engaging in sustainability activities. As suggested, health-promoting factors such as Outdoor experiences, Self-efficacy, and Sense of Coherence, are fundamental to shaping attitudes and promoting sustainable engagement. Single-headed arrows indicate regression scores. Rectangles represent the measured variables listed individually in the Appendix, while the oval represents the latent variable that encompasses health-related competencies.

preserve natural environments), the more inclined they are to acquire information about the environment and ways to preserve and protect it. Ultimately, people need knowledge about sustainability and sustainable behaviors to implement them. Thus, if there is a motivational drive to appreciate, protect, and preserve natural environments, it is only natural to seek information on how to do so (see, also, DeHouwer et al., 2013). Therefore, knowledge scores (the amount of knowledge people gain and retain) can also be viewed as a consequence of learning, as people require a motivational force to engage with and retain information. As such, we observed the typical positive relationship between knowledge and environmental attitude scores (see Table 1: r = 0.46; see Figure 2: b = 0.36; see also Roczen et al., 2014).

Our data further supports the positive relationship between attitude toward nature and environmental attitude of typically around 0.5 (Figure 2; Kaiser et al., 2014; Nisbet et al., 2008). It also suggests that environmental attitude plays a mediating role in the effect of attitude toward nature on learning and environmentally friendly engagement (see, e.g., Baierl et al., 2024; Geng et al., 2015). This is supported by a relatively stronger correlation between environmental attitude and sustainability-related behaviors (see Table 1) than between attitude toward nature and behaviors, also seen in other

studies (e.g., Wells and Lekies, 2006). In other words, the more positive a person's attitude toward nature (their perceived connection to and appreciation for natural environments), the more willingly they preserve and protect it (the stronger their environmental attitudes). This, in turn, leads to enhanced learning about and engagement in sustainability (see also Arbuthnot, 1977), rendering both attitudes relevant for sustainability education.

The question remains on how to enhance attitudes in educational settings. Research indicates that spending time outdoors strengthens a person's connection to and appreciation of nature, resulting in a more positive attitude toward it (e.g., Collado et al., 2020). Multiple studies have demonstrated the positive impact of outdoor experiences on environmental attitudes and behaviors (e.g., Palmer et al., 1998) and even more so on attitudes toward nature (e.g., Kals et al., 1999; Perkins, 2010). However, these positive effects appear to result from regular exposure to nature rather than from short-term isolated experiences (van de Wetering et al., 2022). This is supported by our data, which shows a strong correlation between attitude toward nature and regular outdoor experiences (see Table 1: $r = 0.45$) and a less pronounced relationship between nature exposure and environmental attitudes ($r = 0.26$). Since outdoor experiences, e.g., bonding activities that nurture emotions, shape a person's perceived interconnectedness and relationship with nature, those who spend more time outdoors tend to develop a more positive attitude toward nature. As attitude toward nature appears to drive environmental attitude, we observed a positive yet weaker relationship between outdoor experiences and environmental attitudes. Conversely, less time spent outdoors is associated with less pronounced attitudes toward nature, environmental attitudes, and engagement in pro-environmental activities (Soga and Gaston, 2016).

Many previous studies focused on childhood experiences, while fewer explored the impact of prevalent or educational outdoor experiences on attitude and behavior changes (e.g., Okada et al., 2013; Liu and Green, 2024). Our interest lies in enhancing education and drawing teaching recommendations, which led us to examine the role of present outdoor experiences. This involved the time regularly spent outdoors alone or with company, as well as lessons conducted outdoors or involving natural objects. Consistent through all three subsamples, we found that the more time individuals spent outdoors for leisure, with family or friends, and engaging in outdoor-based teaching, the stronger their attitude toward nature scored (see Table 2 [b = 0.44] and Figure 2 [b = 0.35] for the total sample; and Figures A5–A7 [b = 0.29–0.6] for the subsamples). This, in turn, contributed to more solid environmental attitudes and sustainable engagement. One teaching recommendation may thus involve advocating for outdoor experiences or at least integrating nature objects into the classroom regularly (see also van de Wetering et al., 2022).

The health-promoting factors we considered significantly affect sustainable engagement. This aligns with the United Nations' Sustainable Development Goals, specifically SDG 3, which emphasizes good health and wellbeing. Our data suggest that higher levels of these health-promoting factors such as self-efficacy resulted in more positive attitudes (Figure 2: b = 0.35 for attitude toward nature, and b = 0.14 for environmental attitude), knowledge (Figure 2: b = 23), and behavior scores (for all correlations, see Table 2).

Consistent with previous research (Bandura, 1982), self-efficacy influences attitudes and subsequent behaviors for the total sample (e.g., Table 1: $r = 0.38–0.42$) and across all sub-samples (see Figures A5–A7). Self-efficacy has emerged as a key motivational factor in fostering adaptive and sustainable behaviors, particularly in response to climate change (Van Valkengoed and Steg, 2019). Research indicates that individuals who believe in their ability to influence outcomes are more likely to engage in actions that reduce environmental impact (e.g., Doherty and Webler, 2016; Garfin et al., 2024). This holds especially true for behavior-specific self-efficacy, where direct feedback—such as experiencing the consequences of food choices—enhances perceived control and the intention to act sustainably (Plechatá et al., 2022). In our study, we examined whether general self-efficacy, defined as the belief in one's overall ability to cope with challenges and influence life outcomes (Levenson, 1981), contributes to engagement in sustainability efforts. Using a general self-efficacy scale (Anderson et al., 2005), we found that individuals with higher self-efficacy were more likely to report sustainable attitudes and behaviors. This suggests that broad psychological resources may support environmental action, even beyond targeted interventions.

Supporting health promotion in classroom settings involves enhancing students' self-efficacy, which can be achieved by providing information about specific sustainable behaviors, setting clear goals, and fostering supportive social norms; observing peers engaging in sustainable actions can strengthen individuals' belief in their ability to act (Van Valkengoed et al., 2022). However, self-efficacy varies with task complexity: individuals with high self-efficacy may approach challenging tasks with confidence but underestimate the need for preparation in simpler tasks, while those with low self-efficacy may overprepare for manageable tasks and avoid complex ones due to perceived inability, often accompanied by stress responses (Pajares, 1996; Artino, 2012). Educators should consider these differences when designing instruction, offering personalized feedback, and promoting autonomy—especially in group settings—to align tasks with students' perceived capabilities (Deci and Ryan, 2012). This is particularly relevant in sustainability education, where goals are often abstract and consequences are distant, making it difficult for learners to experience the impact of their actions directly (Hamann et al., 2021; Muenz et al., 2023).

Another important health-promoting factor is an individual's sense of coherence. Rooted in Antonovsky's (1996), the sense of coherence encompasses the capacity to perceive life as comprehensible, manageable, and meaningful. Educational practices that reflect these principles may contribute to strengthening students' sense of coherence. Specifically, instruction should be coherent and transparent, with clear rationales for pedagogical decisions and assessment criteria. A balanced workload—neither excessively demanding nor insufficient—is essential to support students' ability to manage academic challenges. Fostering student involvement in socially legitimate decision-making processes may also enhance their sense of coherence. While life experiences largely shape people's sense of coherence, pedagogical approaches that emphasize transparency and inclusivity can play a supportive role in its development (de Oliveira Olney and Kiss, 2022).

Those may display some teaching recommendations for practical purposes. What our findings do point to are the critical roles of

attitudes and health promotion on its basis. The validity of those factors' roles has been shown for three sub-samples, which may indicate generalizability. Nonetheless, these findings require further confirmation, and additional variables likely contribute to successful sustainability education. We acknowledge cultural differences that may also need further elaboration. One item on plastic bag use, e.g., seemed to be a poor proxy for environmental attitude, probably given different cultural frames in the use of plastics. Then, outdoor experiences had the most decisive impact on attitudes in the Irish cohort. Our data does not conclude whether this effect depends on age, as they were the older university sample, the cultural setting with a probably stronger emphasis on the outdoors, or other factors.

We need to approach the data with caution from a methodological perspective, too. While structural equation modeling is a powerful tool for examining initial relationships among latent constructs, we must recognize its exploratory nature when applied to cross-sectional data. Structural equation modeling primarily reveals covariation and does not establish causality. To draw causal inferences, we would require temporal precedence and eliminate alternative explanations, which cross-sectional designs inherently lack. Therefore, our findings should be interpreted as suggestive of potential relationships rather than definitive causal pathways.

Additionally, the use of cross-sectional data limits the ability to infer directional effects, as exposure and outcome are measured simultaneously. This design may be susceptible to reverse causality, and it does not capture changes over time or the temporal sequence of events (e.g., Savitz and Wellenius, 2022). While cross-sectional studies can still offer valuable insights into associations and inform future longitudinal research, their limitations must be acknowledged.

Finally, reliance on self-reported behavioral indicators, such as those used to assess the ecological footprint, introduces potential response biases, including social desirability and recall inaccuracies. These limitations underscore the need for cautious interpretation and suggest that future studies could benefit from incorporating objective behavioral measures or longitudinal designs to strengthen causal claims.

Our data is not overly conclusive and may set the base for further research. The EU initiative NEB | Lab ECO²-Schools will apply this model for program evaluation. Students participate in educational interventions such as a 2-month solar panel project or a green canteen initiative, and we are about to investigate any changes and relationships related to these variables. For now, our model may provide prompts for researchers and educators, given that cross-sectional data always requires further confirmation.

5 Conclusion

Health-promoting competencies commend the core relationship between knowledge, attitudes, and behaviors. Our data confirmed attitude toward nature's and environmental attitude's supportive roles in learning and sustainable endeavors, and environmental attitude appears to mediate this relationship: The more positive a person's attitude toward nature, the more positive their environmental attitude, which support sustainable behaviors. Based on both attitudes' integral roles in sustainability education, we developed an integrated model with health promotion at its base. We found that higher levels of health-sustaining competencies, such as self-efficacy and sense of coherence, lead to more positive attitudes, which, in turn, support sustainable engagement. Along those lines, outdoor experiences—alone, with others, and for educational purposes—seem beneficial for generating positive attitudes. Educators may thus consider incorporating more outdoor experiences, strengthening people's self-efficacy and sense of coherence, and promoting positive attitudes in sustainability education. While preliminary cross-national analyses across three European countries suggest generalizability, further research is needed to substantiate the foundational role of health promotion in sustainability education.

Data availability statement

The raw data underlying the findings of this article may be made available by the authors upon reasonable request.

Ethics statement

The studies involving humans were approved by the Cork University Ethics Committee (Log 2023-069) and waived for two subsamples as the data was anonymized, ensuring that participants could not be identified, and no sensitive data was collected. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

T-MB: Conceptualization, Data curation, Formal analysis, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. JP: Writing – review & editing. FB: Resources, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1654082/full#supplementary-material

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