frontiers in Education

TYPE Original Research
PUBLISHED 17 March 2026
DOI 10.3389/feduc.2026.1766028

OPEN ACCESS

EDITED BY
Irma Rahma Suwarma,
Indonesia University of Education,
Indonesia

REVIEWED BY
Pooja Sahni,
Indian Institute of Technology Delhi,
India
Matthew Bulbert,
Oxford Brookes University,
United Kingdom

*CORRESPONDENCE
Juliane Fleissner-Martin
juliane.fleissner-martin@uni-bayreuth.de

RECEIVED 11 December 2025
REVISED 21 February 2026
ACCEPTED 24 February 2026
PUBLISHED 17 March 2026

CITATION
Fleissner-Martin J, Baierl T-M, Paul J and Bogner FX (2026) Unlocking green minds: role of attitudes in Edu-escape games.
Front. Educ. 11:1766028.
doi: 10.3389/feduc.2026.1766028

Unlocking green minds: role of attitudes in Edu-escape games

Juliane Fleissner-Martin*, Tessa-Marie Baierl, Jürgen Paul and Franz X. Bogner

Centre for Mathematics and Science Education (Z-MNU), Department of Biology and Chemistry Education, University of Bayreuth, Bayreuth, Germany

Environmental challenges are integral to syllabi to promote pro-environmental behaviors. This study investigated the role of attitudes and their potential to be influenced through an in-class escape game on forest ecosystems and sustainability. The intervention aimed to offset the challenge of incorporating extensive outdoor activities into school life. We assessed 393 8th-graders' attitudes toward nature, environmental attitudes, and knowledge before, immediately after, and 6–9 weeks post-intervention. Stronger initial attitudes correlated with greater and retained knowledge gains. However, the intervention did not alter attitude scores, possibly due to its short duration (4 lessons) or indoor setting, as outdoor activities may better enhance "green" attitudes, aiding knowledge acquisition and nature protective behavior. While the in-class game could not replace outdoor activities in fostering green attitudes, it serves as a resource-efficient complement. Nevertheless, the crucial role of attitudes on learning found in our study might take us one step further to unlocking green minds.

KEYWORDS
attitude assessment with adolescents, attitude toward nature, cognitive learning, environmental attitude, escape game, inclusion of nature in self

1 Introduction

Environmental conservation initiatives play an important role in the syllabus, especially in the face of current environmental challenges such as climate change, biodiversity loss, and pollution. Addressing these challenges requires a comprehensive approach focusing on a deep understanding of and on appreciation for our natural environment so young people persistently engage in pro-environmental endeavors. The literature shows environmental knowledge as fundamental but typically insufficient to evoke persistent behavioral changes (Geiger et al., 2019). While many aspects, such as socioeconomic status (Franzen and Vogl, 2013) or perceived norms (Kollmuss and Agyeman, 2002), either assist or impede personal engagement, attitudes act as internal motivators in supporting learning about environmental issues and for pro-environmental engagement (see, e.g., Nisbet et al., 2008; Frantz and Mayer, 2014; Whitburn et al., 2020).

While there is evidence that attitude toward nature and environmental attitude are critical for pro-environmental engagement (see, e.g., Kesenheimer and Greitemeyer, 2021), we know little about both attitude's relationship in classroom settings and how they can be strengthened in typical syllabi sceneries. This is particularly true for attitude toward nature, as there is little research on adolescents (e.g., Barrera-Hernández et al., 2020; Cheng and Monroe, 2012), although school settings are the usual platforms to reach many people, and adolescence seems to be an important period for developing attitudes (Krettenauer, 2017). Much research on changes in attitudes toward nature has been based on relatively extensive outdoor activities,

such as multi-day residential environmental education programs, repeated field excursions over several weeks, or long-term project-based outdoor learning formats (for summary, see, e.g., Bogner and Wiseman, 2004; DeVille et al., 2021; Rosa and Collado, 2019; Hu and Mou, 2025). While such formats are undoubtedly effective, their regular implementation in everyday school life is not equally feasible across educational systems. In some countries (e.g., Nordic countries; Remmen and Iversen, 2023), regular outdoor schooling is structurally embedded, whereas in other contexts logistical constraints, curriculum pressure, safety regulations, limited access to natural environments, or organizational effort restrict the possibility of implementing longer-term or repeated outdoor programs (Oberle et al., 2021; Waite, 2020). Therefore, complementary classroom-based approaches that provide theoretical grounding and preparatory engagement with environmental topics remain relevant. In this regard, our self-guided escape game may serve either as preparation for out-of-school interventions or, where such interventions are not (yet) feasible, as a stand-alone in-class alternative.

Our research focused on learning more about promoting students' attitudes toward nature in school settings. This refers to attitude toward nature's role in learning and whether a student-centered in-class learning module could improve students' attitudes. While the positive effects of environmental attitude and environmental knowledge on environmental behavior are well documented (e.g., Liu et al., 2020; Kaiser et al., 2007) there is limited research on attitude toward nature on adolescents (see, e.g., Barrera-Hernández et al., 2020). Therefore, this paper aims to fill this gap in the literature by investigating the role of the attitude toward nature in learning, with a specific focus on its assessment in adolescents.

1.1 Environmental attitude's and attitude toward nature's roles in learning and pro-environmental engagement

Both—environmental attitude and attitude toward nature—are motivational drivers for persistent pro-environmental engagement (Taube and Vetter, 2019). Environmental attitude reflects people's propensity and commitment to engage in nature conservation or preservation (see, e.g., Kaiser et al., 2010; Kaiser et al., 2007). Attitude toward nature, on the other hand, reflects people's propensity to appreciate and enjoy nature, shown in contemplative outdoor activities such as stargazing, outdoor sports such as hiking, or other restorative activities in natural environments. In this regard, attitude toward nature is also labeled as people's relatedness with nature (Zelenski and Nisbet, 2014) or their environmental identity (Clayton, 2003), resonating with people's perceived interconnectedness with nature (Schultz, 2002).

If people appreciate nature, we would presume that they are more likely to care for it. Literature shows that the stronger a person's attitude toward nature, the more they engaged in pro-environmental behaviors (see, e.g., Frantz and Mayer, 2014; Markowitz et al., 2012; Whitburn et al., 2020). As such, we can expect people with positive attitudes toward nature to be more committed to its conservation and preservation, which would show in more positive environmental attitudes. A recent study pointed to a causal relationship between both attitudes: Environmental attitude indeed mediated attitude toward nature's effect on environmental knowledge levels (Baierl et al., 2024). It indicates that attitude toward nature is a predecessor of environmental attitude. The stronger a person's attitude toward nature, the stronger their environmental attitude, and the stronger we can expect their knowledge about the environment and their pro-environmental engagement to be.

Attitude toward nature has been mostly assessed with adults, and there is some lack of research on adolescents (Barrera-Hernández et al., 2020; Cheng and Monroe, 2012). Studies with adolescents would, however, help derive teaching recommendations for better guidance toward living more environmentally friendly. This is particularly important as adolescence is a period of attitude consolidation, decisive for adult engagement, and classrooms platforms to reach many people (see Baierl et al., 2022). Therefore, deriving teaching recommendations for school classrooms would be valuable in guiding people toward living more sustainably.

1.2 Enhancing attitudes toward nature and environmental attitudes through educational approaches

Environmental education and Education for Sustainable Development play a role in cultivating learners' "dynamic qualities" (Posch, 1991, p. 11), enabling them to critically analyze, construct, and take action with a high level of autonomy and self-determination. Effective education equips learners with the skills to navigate uncertainty, ambiguous situations, and conflicting divergent norms, values, interests, and perspectives. Besides this foundation, it is important to consider how a positive attitude toward nature can significantly enhance learning and pro-environmental engagement. Numerous studies over the past years have shown that outdoor environmental education programs positively impact environmental knowledge and attitudes (e.g., Olivos et al., 2013; Liefländer et al., 2012; Schmitz and Rocha, 2018). Long-term outdoor engagement is, however, resource-intensive and challenging to align with regular school curricula. Therefore, it is reasonable to define supportive factors in a classroom setting. Educational escape games give some hope due to connecting interactive simulation activities with learning through puzzles and challenges.

Such educational escape games have gained popularity and been utilized as training resources for their interactive learning features. The game-based elements enhance students' learning motivation and problem-solving skills (Borrego et al., 2017; Huang et al., 2020). Other studies show that pro-environmental engagement can be promoted through action-oriented learning, e.g.: The opportunity to make decisions and act (digitally) within a simulation game allowed students to experience immediate feedback and self-efficacy, which supports pro-environmental behavior (Muenz et al., 2023). A study by Parker and Welch (2021) has shown that escape room exercises in simulations can decrease student anxiety and improve learning outcomes by enhancing teamwork, communication skills, and familiarity with simulation environments. Further, by implementing the tasks and contents into a captivating story, students can get emotionally involved, probably leading to better learning outcomes and triggering changes in their attitudes or behavior. Consequently, these benefits could make escape games a feasible addition in environmental education initiatives in relation to resource-intense outdoor sessions and, consequently, for our study.

Building on this, we conceptualize the escape game as a structured learning environment in which specific design features activate distinct psychological and pedagogical mechanisms. Storyline and immersive representation can foster situational interest and affective engagement, thereby supporting intrinsic motivation and flow

experiences (Krath et al., 2021), while puzzles and feedback loops provide immediate performance information and scaffold competence development, both of which are central drivers of motivational and cognitive outcomes (De Freitas, 2018). Moreover, collaborative challenges and guided facilitation (e.g., structured briefing and debriefing) can promote relatedness, reflection, and the transfer of knowledge and attitudes to real-world sustainability contexts (Ahmadov et al., 2025; Freese and Lukosch, 2025), thus offering a theoretically grounded pathway from game mechanics to environmental attitude change and knowledge retention.

1.3 Research goals

Given attitude toward nature's presumed vital role in cognitive learning, we focused on its assessment, its role in learning, and on monitoring supporting factors. Related studies have been mostly concentrating on adult samples. However, as adolescence seems to be a period of attitude consolidation, schools have the potential to act as platforms to guide them toward a more environmentally friendly lifestyle. Based on the Campbell paradigm (Campbell, 1963) and prior findings suggesting that environmental attitudes are associated with learning-related variables, the present study pursued to answer the following research questions:

1 Does the Rasch-calibrated attitude instrument demonstrate satisfactory psychometric properties (e.g., model fit, reliability) within the present adolescent cohort?
2 Will the students with higher initial levels of attitude toward nature show higher cognitive learning outcomes in the intervention context?
3 Is the in-class intervention associated with a measurable change in attitude toward nature, consistent with the assumption that structured engagement can support attitudinal development?

By examining these questions, we aim to clarify the role of environmental attitudes in learning within feasible classroom-based interventions that may prepare for or compensate for extensive outdoor education.

2 Materials and methods

2.1 Participants and procedure

In this study, 393 8th-graders ($M_{age} \pm SD = 13.91 \pm 1.20$ years; 53.6% female; 43.5% male) from college preparatory secondary institutions ("Gymnasium") in Bavaria, Germany, participated. The cohort encompassed schools from diverse localities spanning metropolitan and rural regions. School heads and teachers decided to participate in the study, and legal guardians gave their written consent for student participation.

The educational modules were derived from escape games and implemented in four flexible instructional sessions, either as single blocks or across two double sessions. In collaborative, self-regulated learning groups of 3–4, students engaged in a variety of problem-solving tasks, including experiments, analyzing data and texts related to the forest ecosystem and sustainability issues in ways that the students had to integrate their knowledge and apply critical thinking skills. The educational content addressed topics such as understanding the forest as an ecosystem, its layers, species knowledge of forest trees, succession and deadwood, paper production and recycling, the individual ecological footprint, the three pillars model of sustainability, protective functions of the forest, and pollution issues. Progress through the modules required correctly completing tasks to unlock subsequent challenges, ensuring that all group members contributed actively to the learning process. Teachers monitored group dynamics and provided support when needed. The final reflection and discussion of the sessions encouraged students to connect their experiences with the ecological and sustainability concepts, fostering active learning, critical thinking and metacognitive skills (for further detailed information on the educational intervention, see Fleissner-Martin and Bogner, 2024).

2.2 Measures

The measures covered environmental knowledge, environmental attitude, attitude toward nature, and inclusion of nature in self. While environmental knowledge was assessed thrice, i.e., up to 2 weeks before the learning module (T1), immediately after the module (T2), and about 6–9 weeks after the module as a follow-up evaluation (T3), attitudes and inclusion of nature in self were assessed twice, i.e., before (T1) and 6–9 weeks after the learning module (T3) (see Figure 1). The retention test (T3) was conducted approximately 6–9 weeks after program completion, with the exact timing influenced by organizational constraints (e.g., school holidays). This slight variation in the follow-up interval may have attenuated detectable changes. While precise timing for each student was not available, future studies could include the number of days between T2 and T3 as a covariate to account for potential variability in follow-up duration.

All items were assessed through a digitized, anonymized questionnaire. Environmental knowledge comprised 25 multiple-choice queries with one correct option among three distractors, spanning ecosystem facts, eco-friendly behaviors, and the impact of various technologies (for more information on the items, see Fleissner-Martin et al., 2023). The items were analyzed using a dichotomous Rasch model (see Rasch, 1980), yielding knowledge scores between −2.33 and 3.60 logits ($M = 0.69$, $SD = 0.94$), where logits reflect the natural log odds of providing correct versus incorrect responses. Higher logits

FIGURE 1
Study design including the timeframe of the evaluation ($N = 393$; KN, knowledge; AN, attitude toward nature; EA, environmental attitude; INS, inclusion of nature in self).

indicate stronger knowledge levels. The scale demonstrated an adequate separation reliability (*rel.* = 0.72) and mean square values weighted by the item variance (MS_w) ranged from 0.83 to 1.24, suggesting a robust measure for differentiating individuals' environmental knowledge scores (see also Fleissner-Martin et al., 2023).

To measure environmental attitude, an individual's propensity to protect the environment, we employed 30 items (see Supplementary Table 1) originally derived from two established environmental attitude measures. This compilation of items has been previously validated in its current form by Baierl et al. (2022). The participants responded to these items using two response scales: a 5-point frequency scale ranging from 1, indicating "never," to 5, denoting "always," or a 5-point response pattern where 1 represented "strongly disagree" and 5 "strongly agree." 13 items were negatively formulated, signaling an absence of inclination toward environmental protection, and reverse-coded prior to analysis. The ACERQuest software (Adams and Khoo, 1996) was utilized to administer a basic Rasch model for binary items across all assessment periods, evaluating the integrity of the scale. Therefore, we had to convert all items into a dichotomous format. Answers corresponding to "never," "seldom," "occasionally," along with "strongly disagree," "disagree," or "neutral/unsure" denoted a diminished propensity for environmental conservation and were coded as 0. In contrast, "often," "always," as well as "agree" and "strongly agree" indicated a favorable disposition toward protecting the environment and were thus coded as 1. A notable separation reliability coefficient (*rel.* = 0.78) suggested that the scale reasonably distinguished between the participants. The fit indices, demonstrating the extent of congruence between the Rasch model prediction and empirical response pattern, yielded similarly satisfactory results with MS_w values ranging from 0.87 to 1.19 (Bond and Fox, 2007). Person scores (i.e., logits) ranged between −3.92 and 3.35 ($M = 0.03$; $SD = 0.95$). In this context, logits are understood as the natural logarithmic conversion of the ratio between environmentally protective responses and those that are not. Logit values carry a positive directionality, with higher positive values corresponding with a stronger environmental attitude (see Supplementary Figure 1).

Attitude toward nature was captured with 45 self-reported items (see Supplementary Table 2) related to using natural environments for restoration and recreation. Those items stem from Baierl et al. (2024), who had merged two established measurement tools (Brügger et al., 2011; Bogner and Wiseman, 2004) for a flexible item pool to assess attitude toward nature among adolescents. Within their modification, some items were adapted for broader use for instance, instead of "As a child, I spent time in the woods" it says "As a child, I spent time outdoors." All polytomous items were answered using a 5-point scale that measured frequency (1 = "never" to 5 = "always") or agreement (1 = "strongly disagree" to 5 = "strongly agree"). Dichotomous items required a straightforward "yes" (1) or "no" (0) response, with a "not applicable" option recorded as 0. The four negatively framed items were recalibrated in reverse for the analysis. To mitigate potential measurement error, polytomous items were again transformed into a dichotomous format, coding responses indicative of less engagement with nature (e.g., "never," "seldom," "occasionally," "strongly disagree," "disagree," "neutral/unsure") as 0 and more positive engagement (e.g., "often," "always," "agree," "strongly agree") as 1. We again used the dichotomous Rasch model, which revealed a good separation reliability coefficient (*rel.* = 0.86), evidencing suitable discrimination capability among subjects (see Supplementary Figure 2). Item fit indices were within an appropriate range, with MS_w values for item variance between 0.83 and 1.16 (Bond and Fox, 2007). Person parameters (i.e., logits) ranged from −4.41 to 2.80 ($M = -0.57$; $SD = 1.02$).

Lastly, we employed the Inclusion of Nature in Self Scale developed by Schultz et al. (2002), a one-item scale to assess the participants' perceived connectedness with nature. The scale consists of seven sets of two approaching circles indicating the 'self' and 'nature'. The closer the circles or the stronger their overlap, the more connected the students perceived to be with nature, where 0 indicates little and 7 indicates a tight connection with nature.

3 Results

Our results are presented in three sections: We first tested the attitude toward nature measurement to assure its validity in our chosen age group. Secondly, we investigated attitude toward nature's and environmental attitude's roles in learning about the environment and sustainability-related behaviors. Third, we monitored the 4-h in-class educational intervention regarding its potential to affect attitude scores.

3.1 Calibrating attitude toward nature with adolescents

Calibrating the attitude toward nature pool for adolescents revealed good fit indices, i.e., a strong reliability score and overall good MS_w-values (see Measures, and for fit indices references, Bond and Fox, 2007). Based on those good fit indices and with up to four items capturing the same item difficulty, we were interested in a reduced item set that requires less time for students to complete. So, for more practicability (i.e., shorter questionnaires), we cut the 45-item pool to 25 items, so each behavioral cost is represented only once. The shortened version still revealed a fair reliability score (*rel.* = 0.76) with mean square values weighted by the item variance that fell between 0.88 and 1.12 ($M = 0.99$, $SD = 0.06$). Person parameters ranged from −3.91 to 3.08 logits, and item difficulties, i.e., behavioral costs, ranged from −2.42 to 2.18 logits. The logit person parameters of the original and abbreviated version showed strong correlations between the pre-test scores ($r = 0.943$, $p < 0.001$) and the retention scores ($r = 0.949$, $p < 0.001$), indicating that the abbreviated version did not compromise person score information (see Supplementary Table 2 for further fit indices comparing the original and abbreviated version).

3.2 Attitude toward nature's role in learning

The correlation pattern of both attitudes and inclusion of nature in self with the three knowledge test points is shown in Table 1. Note that the correlations of both attitudes with the students' pre- and retention knowledge scores were larger than those with post-program knowledge scores. The same was true for the inclusion of nature in self scale. Correspondingly, the correlation between attitudes and knowledge changes between the pre- and retention test was significant. At the same time, it was insignificant between the pre- and post-test or the post- and retention test. As such, the correlation of pre-knowledge scores with retention-knowledge scores was also higher than with post-program scores.

Additionally, the correlation between environmental attitude and attitude toward nature ($r = 0.473$, $p < 0.001$; see also Mayer and Frantz, 2004) and a tighter relationship between the inclusion of nature in self

TABLE 1 Correlations between attitudes (attitude toward nature and environmental attitude) and inclusion of nature in self (pre-test), and knowledge levels and gains regarding the three testing points, that is, before the educational intervention (pre-test, T1), right after program completion (post-test, T2), and 6–9 weeks after the intervention to test long-term changes (retention test, T3).

Construct	Correlation coefficient (*r*) and significance (*p*)	Environmental attitude	Attitude toward nature	Inclusion of Nature in Self	Knowledge T1	Knowledge T2	Knowledge T3	Knowledge gain (T2-T1)	Knowledge gain (T3-T2)	Knowledge gain (T3-T1)
EA	*r*	/	**0.473**	**0.316**	**0.407**	**0.355**	**0.433**	0.088	0.109	**0.148**
	p		**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	*n.s.*	*n.s.*	**0.003**
AN	*r*		/	**0.470**	**0.177**	**0.219**	**0.222**	**0.124**	0.009	**0.104**
	p			**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.031**	*n.s.*	**0.039**
INS	*r*			/	**0.243**	**0.173**	**0.281**	0.021	**0.136**	**0.115**
	p				**<0.001**	**0.002**	**<0.001**	*n.s.*	**0.018**	**0.022**
KN T1	*r*				/	**0.551**	**0.580**	**−0.323**	0.088	**−0.217**
	p					**<0.001**	**<0.001**	**<0.001**	*n.s.*	**<0.001**
KN T2	*r*					/	**0.706**	**0.612**	**−0.266**	**0.343**
	p						**<0.001**	**<0.001**	**<0.001**	**<0.001**
KN T3	*r*						/	**0.269**	**0.494**	**0.669**
	p							**<0.001**	**<0.001**	**<0.001**

EA, Environmental attitude; AN, Attitude toward nature; INS, Inclusion of Nature in Self. Bold values indicate statistically significant correlations ($p < 0.05$).

scale and attitude toward nature ($r = 0.470$, $p < 0.001$) than with environmental attitude ($r = 0.316$, $p < 0.001$), speaks of the scale's validity.

In line with those correlations, the connection between attitude and knowledge scores became tighter in the retention test for environmental attitude ($r = 0.488$, $p < 0.001$) and with overall knowledge gains (between the pre- and retention test: $r = 0.262$, $p < 0.001$). The same pattern becomes apparent for attitude toward nature and knowledge scores in the retention test ($r = 0.259$, $p < 0.001$) and with overall knowledge gains (pre- and retention test: $r = 0.140$, $p < 0.001$), indicating a trend of stronger attitude scores aligning with knowledge gains and retains.

In the next step, regression analyses were applied to investigate both attitude's effects on knowledge scores. Attitude toward nature [$F(1, 391) = 20.29$, $p < 0.001$, $R^2 = 0.05$; $\beta = 0.22$] and environmental attitude [$F(1, 391) = 90.40$, $p < 0.001$, $R^2 = 0.19$; $\beta = 0.43$] significantly impacted the knowledge scores student retained, though the effect of environmental attitude appears considerably stronger, which is in line with previous research (e.g., Baierl et al., 2022). Since we are particularly interested in attitude toward nature's role in learning, we further analyzed its effect on knowledge gains (i.e., retention scores minus pre-knowledge scores). The effect of attitude toward nature on knowledge gains [$F(1, 387) = 7.67$, $p = 0.006$, $R^2 = 0.02$; $\beta = 0.14$] is visualized in Figure 2.

Based on both attitudes' positive effect on either knowledge levels or gains and based on environmental attitude's indicated mediating effect (see Baierl et al., 2024), we conducted a mediation test in line with Baron and Kenny (1986) to learn more about their relationship in the learning process. As such, we first investigated attitude toward nature's effect on knowledge gains [Path c; $b = 0.08$, 95% CI (0.01, 0.17), $\beta = 0.10$]. We then looked at path a, which is attitude toward nature's impact on environmental attitude [$b = 0.41$, 95% CI (0.34, 0.49), $\beta = 0.47$], and path b, which is environmental attitude's effect on knowledge gains [$b = 0.13$, 95% CI (0.02, 0.23), $\beta = 0.13$]. Once we added the mediator, attitude toward nature's effect on knowledge gains turned insignificant [path c'; $b = 0.04$, 95% CI (−0.06, 0.13), $\beta = 0.04$] (see Figure 3).

3.3 Program effects on attitude toward nature and environmental attitude

Analyses of changes in attitude toward nature, environmental attitude, and inclusion of nature in self scores indicated a statistically significant decrease in attitude toward nature scores between the pre-test and the retention test, with a mean difference of −0.142 ($SD = 0.821$, $SEM = 0.042$), $t(387) = -3.408$, $p < 0.001$, $d = -0.173$ (see Table 2 for additional data). Although there was a significant decrease, the effect is negligible due to Cohen's d being smaller than 0.2. The same was observed for the inclusion of nature in self scores, with a mean difference of −0.140 ($SD = 1.078$, $SEM = 0.054$), $t(392) = -2.574$, $p = 0.010$, $d = -0.130$. There was no change in environmental attitude scores [mean difference of −0.050 ($SD = 0.728$, $SEM = 0.037$), $t(391) = -1.364$, $p = 0.173$, $d = -0.069$].

4 Discussion

4.1 Assessing attitude toward nature with adolescents

As the complete 45-item pool yielded favorable fit indices, strong reliability scores, and overall satisfactory MS_w-values, the scale's

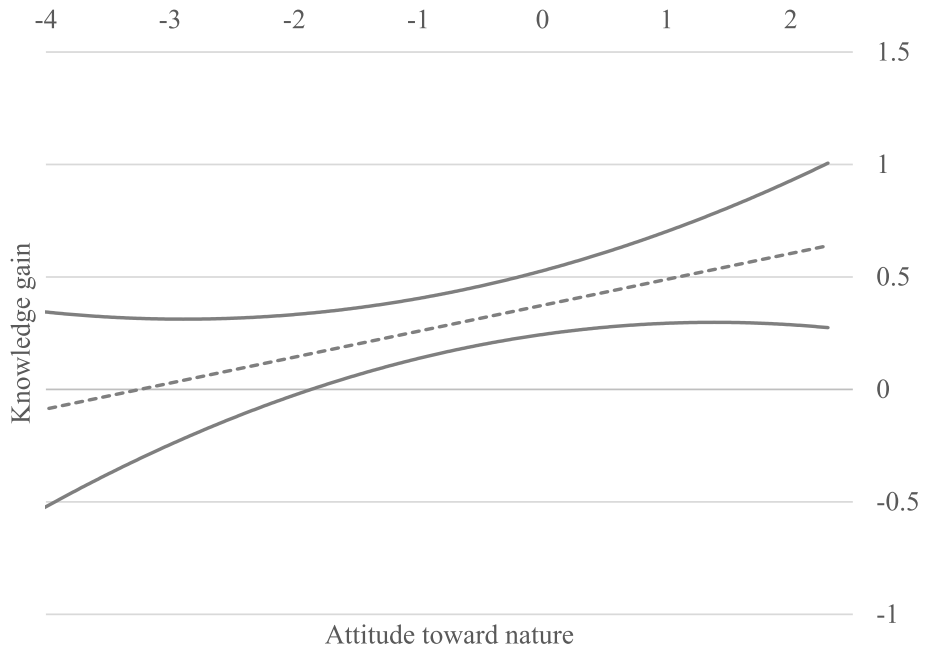

FIGURE 2
Attitude toward nature's effect on knowledge gains, i.e., the difference between the retention knowledge scores and the knowledge scores before the educational intervention; the dashed line shows the trend line, while the solid lines reflect the effective confidence intervals. The more positive the students' attitude toward nature was, the more knowledge they gained.

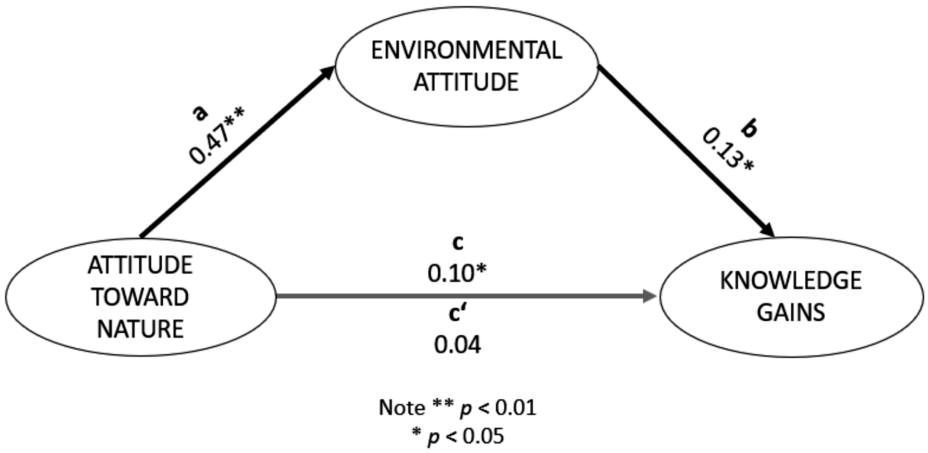

FIGURE 3
Attitude toward nature's role in learning about environmental issues; with environmental attitude as a mediator, the effect of attitude toward nature on the students' knowledge gains (i.e., retention scores minus pre-scores) turned insignificant.

TABLE 2 Pre- and retention test mean scores, sample sizes, standard deviation, and standard error of mean for all attitudes.

Attitude scale	Testing point	*M*	*N*	*SD*	*SEM*
Inclusion of nature in self	Pre	4.14	393	1.239	0.062
	Retention	4.00	393	1.254	0.063
Attitude toward nature	Pre	−0.4920	388	1.01427	0.05149
	Retention	−0.6340	388	1.02989	0.05228
Environmental attitude	Pre	0.0601	392	0.88298	0.04460
	Retention	0.0099	392	1.00222	0.05062

appropriateness with adolescents is proven. However, the extensive number of items is time-consuming for the collaborating teaching staff and runs the risk of participants completing them insufficiently (Eisele et al., 2022). Additionally, with lengthy questionnaires, items toward the end tend to be responded to with less consideration than those at the beginning (Galesic and Bosnjak, 2009). Long

questionnaires may thus compromise the data quality. Consequently, we investigated the adequacy of a reduced item set from the proposed measurement pool. Subsequent analysis of the shortened 25 item-version indicated similarly satisfactory fit values, and the scale could still differentiate well among the participants. This suggests that the item pool is a reliable proxy for assessing adolescents' attitudes toward nature. In conclusion, refining the item pool to 25 items maintained the reliability and validity of the complete item pool for adolescents, and further reductions appear promising. Streamlining the scale through item reduction could enhance its practicality and applicability without compromising the data quality. This may encourage researchers to carefully select fewer but relevant items for their specific study cohort, considering item difficulties and fit values to ensure accurate and valid findings. As such, the item pool allows flexibility for the items to match the cohort (i.e., culturally and geographically) while maintaining interstudy comparability.

4.2 The impact of attitude toward nature, environmental attitude, and inclusion of nature in self on students' learning

Secondly, we investigated the influence of attitude toward nature, environmental attitude, and inclusion of nature in self on the students' environmental knowledge scores and gains. Our study revealed overall positive correlations between individuals' attitudes and the levels of environmental knowledge they previously had, acquired, and retained. The correlations of attitude toward nature, environmental attitude, and the inclusion of nature in the self-scale were most prominent with long-term knowledge scores, indicating that those with more positive attitudes could acquire long-term knowledge. It suggests that those with positive attitudes were indeed more committed to nature protection and conservation, reflected by their probably deeper engagement in and out of class.

This is particularly true for environmental attitude: Those with more positive environmental attitude scores knew more about the topic before the intervention and gained more knowledge in the long run. In contrast, the relationship with post-program knowledge scores is less tight (for similar results on a similar intervention, see Baierl and Bogner, 2024). This indicates that those with a more positive attitude engaged more in the topic before the intervention and the learning activities. It resonates with previous findings that those with more positive attitudes are more likely to take learning opportunities and to engage more rigorously in the learning opportunities given, which is reflected by a tighter connection with pre- and retention-knowledge scores and with long-term knowledge gains (Baierl et al., 2022). Those with less positive attitudes gained mostly only short-term knowledge (i.e., knowledge scores right after the intervention), probably less committed to the topic, and rather inclined with baseline classroom instructions (see also Baierl and Bogner, 2024).

In addition to cognitive factors, such as intelligence, diverse aspects influence learning and play a role in academic achievement (Weber et al., 2013), such as earning teachers' recognition or gaining peer admiration (Urdan and Maehr, 1995). However, the students' environmental attitudes may also serve as a critical determinant, not only spurring their actions toward environmental preservation (Taube and Vetter, 2019) but also influencing their active pursuit of new learning opportunities (Taube et al., 2021) and their deep engagement with environmental conservation initiatives (Henn et al., 2019). Consequently, differences in the intensity of students' learning efforts logically lead to variations in their knowledge levels, even within the same instructional environment. The association of attitudes and knowledge levels emphasizes the vital role of positive attitudes in enhancing the effectiveness of environmental education efforts. Our results point to the importance of cultivating favorable attitudes toward nature and the environment to foster a more profound understanding and acquisition of environmental knowledge among students. After all, besides other factors such as socioeconomic status (Franzen and Vogl, 2013), attitudes are more likely to be affected through classroom teaching.

Our research further elaborated on attitude toward nature's foundational role in shaping environmental attitude and, consequently, cognitive learning. Previous research revealed environmental attitude's mediating effect in learning: While attitude toward nature positively affects the student's long-term knowledge scores, environmental attitude fully mediates their relationship, rendering attitude toward nature a predecessor of environmental attitude and learning (Baierl et al., 2024). Our findings advance those and demonstrate environmental attitude's mediating effect on the student's knowledge retention.

Kaiser et al. (2014) described a mutual connection between attitude toward nature and environmental attitude. They observed these attitudes to be quite stable, noting that if any changes occurred, they were likely to increase simultaneously. Our results support the connection between individuals' attitude levels and receptiveness to environmental concepts and learning experiences; attitudes appear to act as a fundament for learning success. Consequently, developing educational approaches that strengthen attitudes becomes decisive, e.g., by integrating nature-based elements (Collado et al., 2020; Genc et al., 2018), outdoor learning opportunities (Rios and Brewer, 2014), and experiential activities. Embedding these approaches within curricular recommendations and educational initiatives could yield substantial benefits in promoting environmental consciousness and fostering sustainable behaviors.

4.3 The interventions' effects on students' attitude toward nature, environmental attitude, and inclusion of nature in self

Lastly, we examined the impact of our interventions on the levels of attitude toward nature, environmental attitude, and inclusion of nature in self among the participants. Our analysis only showed negligible differences (all effect sizes $d < 0.2$; see chapter 3.3) in the students' attitudes before and after our short-term interventions. This finding aligns with some existing literature, indicating that isolated short-term interventions may not be sufficient to elicit considerable changes in attitude toward nature and environmental attitude (e.g., Bogner and Wiseman, 2004; Liefländer and Bogner, 2016). Additional research suggests that long-term engagement with nature-based experiences by integrating education for sustainable development into regular classroom practices is effective in fostering lasting attitude changes (Bogner, 1998; Bogner and Wiseman, 2004; Duerden and Witt, 2010). Additionally, our findings, with the limited impact of short-term interventions, highlight the need for comprehensive and continuous approaches. Integrating outdoor interventions into isolated learning units may not adequately address the complexities of attitude formation and

behavior change. Instead, it seems imperative to create opportunities for meaningful encounters with nature and incorporate environmental education into various aspects of the curriculum. Utilizing outdoor educational settings (Genc et al., 2018), engaging in experience-based learning (Ballantyne and Packer, 2008), and integrating sustainability principles across subjects might be key to fostering positive attitudes toward nature and environmental conservation among students.

5 Conclusion

Attitudinal preferences influence cognitive learning about sustainability-related issues, producing a clear pattern: The higher a person's attitude level scored, the more knowledge was gained and retained. Attitude levels apparently act as triggers in the educational channel. Consequently, schools in general should concentrate on fostering attitudes to enable effective learning, which in the long-range may lead to favorable behavioral changes toward sustainability. Unsurprisingly, our short-term in-classroom intervention did not yet induce significant changes in students' environmental attitudes, which underlines the importance of long-term interventions, so to say, as hidden syllabus in all classroom actions during school life. With continuous nature-based experiences within sustainable principles a realistic chance of being internalized by the students is given. Eventually, it will lead to facilitate long-lasting shifts in attitudes and behaviors toward the environment.

Data availability statement

The datasets presented in this article are not readily available because of the Bavarian Ministry for Education's guidelines regarding data of underaged participants. Requests to access the datasets should be directed to juliane.fleissner-martin@uni-bayreuth.de.

Ethics statement

The studies involving humans were approved by the Bavarian Ministry of Education (Bayerisches Staatsministerium für Bildung und Kultus; StMBK) under Grant (IV.7-BO4106.2022/6/13, 31.05.2022). 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

JF-M: Formal analysis, Data curation, Visualization, Methodology, Conceptualization, Writing – original draft. T-MB: Formal analysis, Visualization, Data curation, Writing – review & editing. JP: Writing – review & editing. FXB: Funding acquisition, Writing – review & editing.

Funding

The author(s) declared that financial support was received for this work and/or its publication. This work was supported by the Bavarian Ministry of Education (Bayerisches Staatsministerium für Bildung und Kultus; StMBK) under Grant (IV.7-BO4106.2022/6/13, 31.05.2022), and the University of Bayreuth.

Acknowledgments

We extend our gratitude to all the schools, teachers, and students who participated in this study. We also thank the Bavarian Ministry of Education (Bayerisches Staatsministerium für Bildung und Kultus; StMBK) for authorizing our research (IV.7-BO4106.2022/6/13, 31.05.2022), and the University of Bayreuth for their support.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was not used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2026.1766028/full#supplementary-material

References

Adams, R. J., and Khoo, S.-T.. (1996). Acer Quest: the Interactive test Analysis system (Version 2.1). Camberwell, Victoria: Australian Council for Educational Research. Available online at: https://research.acer.edu.au/measurement/3/.

Ahmadov, T., Karimov, A., Durst, S., Saarela, M., Gerstlberger, W., Wahl, M. F., et al. (2025). A two-phase systematic literature review on the use of serious games for sustainable environmental education. *Interact. Learn. Environ.* 33, 1945–1966. doi: 10.1080/10494820.2024.2414429

Baierl, T.-M., and Bogner, F. X. (2024). Cognitive learning about forests: the key role of environmental attitude. *Int. J. Sci. Educ.* 47, 358–378. doi: 10.1080/09500693.2024.2323917

Baierl, T.-M., Kaiser, F. G., and Bogner, F. X. (2022). The supportive role of environmental attitude for learning about environmental issues. *J. Environ. Psychol.* 81:101799. doi: 10.1016/j.jenvp.2022.101799

Baierl, T.-M., Kaiser, F. G., and Bogner, F. X. (2024). The role of attitude toward nature in learning about environmental issues. *Front. Psychol.* 15:1471026. doi: 10.3389/fpsyg.2024.1471026

Ballantyne, R., and Packer, J. (2008). Introducing a fifth pedagogy: experience-based strategies for facilitating learning in natural environments. *Envir. Educ. Res.* 15, 243–262. doi: 10.1080/13504620802711282

Baron, R., and Kenny, D. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J. Pers. Soc. Psychol.* 51, 1173–1182. doi: 10.1037//0022-3514.51.6.1173

Barrera-Hernández, L. F., Sotelo-Castillo, M. A., Echeverría-Castro, S. B., and Tapia-Fonllem, C. O. (2020). Connectedness to nature: its impact on sustainable Behaviors and happiness in children. *Front. Psychol.* 11:276. doi: 10.3389/fpsyg.2020.00276

Bogner, F. X. (1998). The influence of short-term outdoor ecology education on long-term variables of environmental perspective. *J. Environ. Educ.* 29, 17–29. doi: 10.1080/00958969809599124

Bogner, F., and Wiseman, M. (2004). Outdoor ecology education and pupils' environmental perception in preservation and utilisation. *Sci. Educ. Int.* 15, 27–48.

Bond, T. G., and Fox, C. M. (2007). *Applying the Rasch Model: Fundamental Measurement in the human Sciences*. New York, NY: Routledge.

Borrego, C., Fernández, C., Blanes, I., and Robles, S. (2017). Room escape at class: escape games activities to facilitate the motivation and learning in computer science. *J. Technol. Sci. Educ.* 7, 162–171. doi: 10.3926/JOTSE.247

Brügger, A., Kaiser, F. G., and Roczen, N. (2011). One for all? *Eur. Psychol.* 16, 324–333. doi: 10.1027/1016-9040/a000032

Campbell, D. T. (1963). "Social attitudes and other acquired Behavioral dispositions," in *Psychology: A Study of a Science. Study II. Empirical Substructure and Relations with other Sciences. Volume 6. Investigations of man as socius: their place in psychology and the social Sciences*, vol. 6 (New York: McGraw-Hill), 94–172.

Cheng, J. C.-H., and Monroe, M. C. (2012). Connection to nature. *Environ. Behav.* 44, 31–49. doi: 10.1177/0013916510385082

Clayton, S. (2003). "Environmental identity: a conceptual and an operational definition," in *Identity and the natural Environment. The Psychological Significance of Nature*, eds. S. Clayton and S. Opotow (Cambridge, Mass: MIT Press), 45–65.

Collado, S., Rosa, C. D., and Corraliza, J. A. (2020). The effect of a nature-based environmental education program on children's environmental attitudes and behaviors: a randomized experiment with primary schools. *Sustainability* 12:6817. doi: 10.3390/su12176817

De Freitas, S. (2018). Are games effective learning tools? A review of educational games. *J. Educ. Technol. Soc.* 21, 74–84.

DeVille, N. V., Tomasso, L. P., Stoddard, O. P., Wilt, G. E., Horton, T. H., Wolf, K. L., et al. (2021). Time spent in nature is associated with increased pro-environmental attitudes and behaviors. *Int. J. Environ. Res. Public Health* 18:7498. doi: 10.3390/ijerph18147498

Duerden, M. D., and Witt, P. A. (2010). The impact of direct and indirect experiences on the development of environmental knowledge, attitudes, and behavior. *J. Environ. Psychol.* 30, 379–392. doi: 10.1016/j.jenvp.2010.03.007

Eisele, G., Vachon, H., Lafit, G., Kuppens, P., Houben, M., Myin-Germeys, I., et al. (2022). The effects of sampling frequency and questionnaire length on perceived burden, compliance, and careless responding in experience sampling data in a student population. *Assessment* 29, 136–151. doi: 10.1177/1073191120957102

Fleissner-Martin, J., and Bogner, F. X. (2024). Save the forests!—gamified learning. *Am. Biol. Teach.* 86, 193–200. doi: 10.1525/abt.2024.86.4.193

Fleissner-Martin, J., Bogner, F. X., and Paul, J. (2023). Digital vs. analog learning—two content-similar interventions and learning outcomes. *Forests* 14:1807. doi: 10.3390/f14091807

Frantz, C. M., and Mayer, F. (2014). The importance of connection to nature in assessing environmental education programs. *Stud. Educ. Eval.* 41, 85–89. doi: 10.1016/j.stueduc.2013.10.001

Franzen, A., and Vogl, D. (2013). Two decades of measuring environmental attitudes: a comparative analysis of 33 countries. *Glob. Environ. Chang.* 23, 1001–1008. doi: 10.1016/j.gloenvcha.2013.03.009

Freese, M., and Lukosch, H. K. (2025). Structured briefing: towards meaningful learning experiences with simulation games. *Comput. Educ.* 240:105461. doi: 10.1016/j.compedu.2025.105461

Galesic, M., and Bosnjak, M. (2009). Effects of questionnaire length on participation and indicators of response quality in a web survey. *Public Opin. Q.* 73, 349–360. doi: 10.1093/poq/nfp031

Geiger, S., Geiger, M., and Wilhelm, O. (2019). Environment-specific vs. general knowledge and their role in pro-environmental behavior. *Front. Psychol.* 10:718. doi: 10.3389/fpsyg.2019.00718

Genc, M., Genc, T., and Rasgele, P. G. (2018). Effects of nature-based environmental education on the attitudes of 7th grade students towards the environment and living organisms and affective tendency. *Int. Res. Geogr. Environ. Educ.* 27, 326–340. doi: 10.1080/10382046.2017.1382211

Henn, L., Taube, O., and Kaiser, F. G. (2019). The role of environmental attitude in the efficacy of smart-meter-based feedback interventions. *J. Environ. Psychol.* 63, 74–81. doi: 10.1016/j.jenvp.2019.04.007

Hu, R., and Mou, S. (2025). Outdoor education for sustainable development: a systematic literature review. *Sustainability* 17:3338. doi: 10.3390/su17083338

Huang, S., Kuo, Y., and Chen, H. (2020). Applying digital escape rooms infused with science teaching in elementary school: learning performance, learning motivation, and problem-solving ability. *Think. Skills Creat.* 37:100681. doi: 10.1016/j.tsc.2020.100681

Kaiser, F. G., Brügger, A., Hartig, T., Bogner, F. X., and Gutscher, H. (2014). Appreciation of nature and appreciation of environmental protection: how stable are these attitudes and which comes first? *Eur. Rev. Appl. Psychol.* 64, 269–277. doi: 10.1016/j.erap.2014.09.001

Kaiser, F. G., Byrka, K., and Hartig, T. (2010). Reviving Campbell's paradigm for attitude research. *Person. Soc. Psychol. Rev.* 14, 351–367. doi: 10.1177/1088868310366452

Kaiser, F. G., Oerke, B., and Bogner, F. X. (2007). Behavior-based environmental attitude: development of an instrument for adolescents. *J. Environ. Psychol.* 27, 242–251. doi: 10.1016/j.jenvp.2007.06.004

Kesenheimer, J. S., and Greitemeyer, T. (2021). Going green (and not being just more pro-social): do attitude and personality specifically influence pro-environmental behavior? *Sustainability* 13:3560. doi: 10.3390/su13063560

Kollmuss, A., and Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* 8, 239–260. doi: 10.1080/13504620220145401

Krath, J., Schürmann, L., and Von Korflesch, H. F. (2021). Revealing the theoretical basis of gamification: a systematic review and analysis of theory in research on gamification, serious games and game-based learning. *Comput. Hum. Behav.* 125:106963. doi: 10.1016/j.chb.2021.106963

Krettenauer, T. (2017). Pro-environmental behavior and adolescent moral development. *J. Res. Adolesc.* 27, 581–593. doi: 10.1111/jora.12300

Liefländer, A. K., and Bogner, F. (2016). Educational impact on the relationship of environmental knowledge and attitudes. *Environ. Educ. Res.* 24, 370–384. doi: 10.1080/13504622.2016.1188265

Liefländer, A. K., Fröhlich, G., Bogner, F. X., and Schultz, P. W. (2012). Promoting connectedness with nature through environmental education. *Environ. Educ. Res.* 19, 370–384. doi: 10.1080/13504622.2012.697545

Liu, P., Teng, M., and Han, C. (2020). How does environmental knowledge translate into pro-environmental behaviors?: the mediating role of environmental attitudes and behavioral intentions. *Sci. Total Environ.* 728:138126. doi: 10.1016/j.scitotenv.2020.138126

Markowitz, E. M., Goldberg, L. A., Ashton, M.- C., and Lee, K. (2012). Profiling the "pro-environmental individual": a personality perspective. *J. Pers.* 80, 81–111. doi: 10.1111/j.1467-6494.2011.00721.x

Mayer, F., and Frantz, C. M. (2004). The connectedness to nature scale: a measure of individuals' feeling in community with nature. *J. Environ. Psychol.* 24, 503–515. doi: 10.1016/j.jenvp.2004.10.001

Muenz, T. S., Schaal, S., Groß, J., and Paul, J. (2023). How a digital educational game can promote learning about sustainability. *Sci. Educ. Int.* 34, 293–302. doi: 10.33828/sei.v34.i4.5

Nisbet, E. K., Zelenski, J. M., and Murphy, S. A. (2008). The nature relatedness scale: linking individuals' connection with nature to environmental concern and behavior. *Environ. Behav.* 41, 715–740. doi: 10.1177/0013916508318748

Oberle, E., Zeni, M., Munday, F., and Brussoni, M. (2021). Support factors and barriers for outdoor learning in elementary schools: a systemic perspective. *Am. J. Health Educ.* 52, 251–265. doi: 10.1080/19325037.2021.1955232

Olivos, P., Aragones, J., and Navarro, O. (2013). Environmental education: itineraries in nature and their relationship with connectedness, environmental concerns and behavior. *Rev. Latinoam. Psicol.* 45, 501–511.

Parker, K., and Welch, T. (2021). Innovative teaching strategies to escape the anxiety in simulation. *Teach. Learn. Nurs.* 16, 414–417. doi: 10.1016/J.TELN.2021.06.005

Posch, P. (1991). "Environment and school initiatives," in *Environment, Schools, and Active Learning*, eds. K. Kelly-Elaine and P. Posch (Paris: OECD).

Rasch, G. (1980). *Probabilistic Models for some Intelligence and Attainment Tests*. Chicago, IL: The University of Chicago Press.

Remmen, K. B., and Iversen, E. (2023). A scoping review of research on school-based outdoor education in the Nordic countries. *J. Adventure Educ. Outdoor Learn.* 23, 433–451. doi: 10.1080/14729679.2022.2027796

Rios, J. M., and Brewer, J. (2014). Outdoor education and science achievement. *Appl. Environ. Educ. Commun.* 13, 234–240. doi: 10.1080/1533015x.2015.975084

Rosa, C. D., and Collado, S. (2019). Experiences in nature and environmental attitudes and behaviors: setting the ground for future research. *Front. Psychol.* 10:763. doi: 10.3389/fpsyg.2019.00763

Schmitz, G., and Rocha, J. B. (2018). Environmental education program as a tool to improve children's environmental attitudes and knowledge. *Education*. 18:10.5923/j.edu.20180802.01.

Schultz, W. P. (2002). "Knowledge, information, and household recycling: examining the knowledge-deficit model of behavior change," in *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, eds. T. Dietz and P. C. Stern (Washington DC: National Academy Press), 67–82. doi: 10.5923/j.edu.20180802.01

Taube, O., Ranney, M. A., Henn, L., and Kaiser, F. G. (2021). Increasing people's acceptance of anthropogenic climate change with scientific facts: is mechanistic information more effective for environmentalists? *J. Environ. Psychol.* 73:101549. doi: 10.1016/j.jenvp.2021.101549

Taube, O., and Vetter, M. (2019). How green defaults promote environmentally friendly decisions: attitude-conditional default acceptance but attitude-unconditional effects on actual choices. *J. Appl. Soc. Psychol.* 49, 721–732. doi: 10.1111/jasp.12629

Urdan, T. C., and Maehr, M. (1995). Beyond a two-goal theory of motivation and achievement: a case for social goals. *Rev. Educ. Res.* 65, 213–243. doi: 10.3102/00346543065003213

Waite, S. (2020). Where are we going? International views on purposes, practices and barriers in school-based outdoor learning. *Educ. Sci.* 10:311. doi: 10.3390/educsci10110311

Weber, J., Lu, L., Shi, J., and Spinath, F. (2013). The roles of cognitive and motivational predictors in explaining school achievement in elementary school. *Learn. Individ. Differ.* 25, 85–92. doi: 10.1016/j.lindif.2013.03.008

Whitburn, J., Linklater, W. L., and Abrahamse, W. (2020). Meta-analysis of human connection to nature and proenvironmental behavior. *Conserv. Biol.* 34, 180–193. doi: 10.1111/cobi.13381

Wright, B. D., and Masters, G. N. (1982). *Rating scale Analysis: Rasch Measurement*. Chicago, IL: Mesa Press.

Zelenski, J. M., and Nisbet, E. K. (2014). Happiness and feeling connected: the distinct role of nature relatedness. *Environ. Behav.* 46, 3–23. doi: 10.1177/0013916512451901