Journal of Outdoor and Environmental Education
https://doi.org/10.1007/s42322-026-00247-6

RESEARCH

Lost in the digital forest? Rethinking childhood between screens and nature

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Received: 1 September 2025 / Revised: 23 January 2026 / Accepted: 1 February 2026

Abstract

Childhood is a critical stage in the development of our individual identities. It is precisely the time when a child begins to become increasingly affected by two processes that may be acting in a manner that is inversely proportional to their educational needs: on the one hand, hyperconnectivity as a cultural reality in childhood and, on the other, a nature deficit. Against this backdrop, this article describes a research process designed to analyse the ludic and didactic use made in childhood of technology and the natural environment, further considering the role played by variables such as gender, age, and school year. This process is of a quantitative, non-experimental, and cross-sectional nature, adopting an exploratory-descriptive and correlational approach. The sample consists of 2,586 schoolchildren aged between 9 and 13. The findings reveal significant differences depending on gender: girls are more engaged with nature, while boys tend more toward technology. There are also differences between school years and the children's ages, with a highlight being a steady decrease in the ludic use of nature and its appreciation as children grow older, especially between the ages of 10 and 12. The study suggests that schools may have a key role to play is reversing these trends, especially using active methodologies and curricular proposals that bring the experience of nature into the classroom. Finally, the discussion focuses on the importance of designing teaching practices that strike a balance between technology and nature with a view to fostering children's sustainable and mindful development in the digital era.

Keywords Hyperconnectivity · Digital technology · Nature · Deficit · Gender · Childhood · Education

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Published online: 22 April 2026

Introduction

Human beings naturally depend on the material and social environment that surrounds us for our fully rounded development. Over the course of history, this environment has been formed through a symbiotic process involving the natural and artificial worlds. On the one hand, what occurs and exists in nature responds to biological criteria expressed in our genes, whereby we cannot escape from it and would be remiss to ignore it. On the other hand, we are what we are today, both as a species and as individuals, thanks largely to technology, which has certain specific effects that shape us, rendering it important to study the extent of their impact at any given time (Stiegler, 1998).

The relationship we now have with technology seems to have strengthened in detriment to our engagement with nature and, moreover, the instrumental logic that defines technological development is also reflected in the way in which we observe the natural world and transmit it to the next generations (Alonso del Casar, 2025). Hyperconnectivity has become childhood's new cultural reality. Children now spend more and more time surrounded by screens and online (Capaldi et al., 2015). In step with the emergence of this phenomenon, Richard Louv (2008) has identified what we now know as Nature-Deficit Disorder, a term that refers to children's growing detachment from nature compared to their parents and grandparents.

The convergence of these two tendencies, compounded by today's scenario of climate crisis, might have substantial long-term repercussions, as the decrease in contact with nature and its instrumentalisation weaken the eco-awareness of new generations and undermine their commitment to its preservation (Kimmerer, 2020). Nevertheless, all is not lost. As the French psychoanalyst and thinker Félix Guattari (1999) affirmed some years ago, although a given socioeconomic system appears to impose the development of a certain subjectivity, children and young people always have ways and means for establishing their own alternative processes of individualisation, above all if their education encourages them to do so.

Faced with this reality, there is a need to develop classroom practices that encourage children and young people to become more aware of nature's importance even in a world dominated by artifice; in other words, this research is designed to help us advance towards a sustainable future in which technology and nature coexist in harmony. We analyse the extent to which children adopt a ludic and didactic approach to nature, considering the role played by such variables as gender, age, and school year.

Literature review

Childhood, digital identity and nature deficit

Childhood is a critical stage for the development and meaning of "self". The experiences we have at this time in our lives have an impact on the building of our own identities in terms of values, outlooks, feelings, beliefs, and behaviours (Dewey, 2021). It is precisely at this stage when a child begins to be increasingly affected by two processes that might be acting in an inversely proportional way to their educa-

tional needs: on the one hand, hyperconnectivity as a cultural reality in childhood, with both girls and boys becoming accustomed to going online, being surrounded by screens, information, and data (Caballero et al., 2024), and on the other, a nature deficit that begins to appear at these ages and is reflected in a weak attachment to their natural environment (Gutiérrez-Pérez et al., 2024a, b). Furthermore, recent research highlights that digital engagement begins even earlier than previously assumed: the use of tablets, smartphones and streaming content is now widespread among preschool-age children, generating early patterns of digital attachment that can persist into later childhood (Harverson, et al., 2025). Including the preschool stage broadens the scope of concern and underscores how deeply technology penetrates children's developmental trajectories from the outset.

This reality presents a potential conflict when technology becomes a consumer item that causes dependency and weakens the building of an individual identity (Anitha et al., 2021). In turn, a child's innate need to engage with nature is gradually displaced, altering the fundamental link between human beings and their natural environment, thereby compromising their rounded development. First of all, a deeper understanding of the relationship between hyperconnectivity and childhood identity requires drawing on theories of digital attachment and self-extension. Muñoz (2021) describe how, in hyperconnected contexts, digital devices become symbolic artefacts through which children negotiate autonomy, belonging and (self)recognition. From this perspective, tablets and smartphones operate as "transitional objects" that mediate affective security, social presence and self-presentation. Such ideas resonate with Stiegler's (1998) account of technics as constitutive of human individuation: digital artefacts do not merely accompany development but actively co-produce subjectivity. Recent analyses of the "onlife self" further argue that digital technologies act as *grammars* shaping how children perceive and narrate themselves, dissolving boundaries between online and offline life. These socio-technical environments mediate children's visibility, relationality and identity construction, making early digital practices formative rather than merely instrumental (Sánchez-Rojo et al., 2022). From an outdoor education perspective, recent work highlights that mobile technologies increasingly operate as mediating tools that reshape how children experience, document and interpret outdoor and natural settings, rather than simply distracting them from such experiences (Beames & Maher, 2024). Integrating these frameworks allows us to understand why early digital engagement, which increasingly beginning in the preschool years (Harverson et al., 2025), can contribute to stable patterns of technological attachment that continue to shape children's interests and daily practices in late childhood (Yau & Reich, 2019).

The phenomenon of hyperconnectivity is confirmed by the data on children's online use. According to the UK Office for National Statistics (Stripe, 2020), 89% of children aged between 10 and 15 state they go online every day. In turn, the latest survey conducted by EU Kids Online (Smahel et al., 2020) reveals that 80% of children access the internet via their smartphones, with boys showing a greater preference for mobile technology (Serrate-González et al., 2025). At the same time, an increasing body of research is warning of the risk arising from the use of digital devices in childhood. Some studies have identified *data misuse*, *and the consumption of harmful or sexual content* even at the age of nine (Caballero et al., 2024; Torrijos-Fincias et al., 2021),

involvement in cases of abuse and cyberbullying (Millan Ghisleri and Caro Samada, 2021), and even addiction to videogames from the age of 11 onwards (Kilbey, 2017). Other studies find that constant access to electronic devices not only transforms the way children interact with their environment, as it also impacts upon their cognitive and emotional development (Otrel-Cass, 2022). Faced with this scenario, some studies have begun to address this issue, analysing the possible correlation between the intensive use of technology and the shorter time spent in outdoor pursuits (Bezeljak et al., 2023; Larson et al., 2019; Selden, 2024; Thorsteinsson et al., 2023).

On the other hand, regarding the importance of our contact with the natural environment for our development as human beings, Wilson's biophilia hypothesis (1984) proposes an innate human tendency to affiliate with natural environments, a predisposition reinforced during childhood through repeated direct contact. Wilson emphasises that this predisposition is not fixed, but activated, strengthened or weakened through experience. During childhood, the hypothesis, supported by contemporary research (Chawla, 2020), suggests that direct, repeated and varied contact with natural spaces, such as playing outdoors, exploring green areas, interacting with animals or manipulating natural materials, acts as a developmental catalyst that reinforces the biophilic tendency. These early interactions help children cultivate attentional capacities, emotional regulation, empathy toward non-human life and a sense of belonging within natural systems. Building on this foundation and adapting to the new realities in which children live (urban environments, limited access to natural settings…), it is important to mention that recent studies distinguish between physical nature**,** referring to unmediated, sensory-rich interaction with natural settings (Capaldi, et al., 2015); hybrid nature**,** which involves structured or tool-supported encounters such as school gardens or guided observation (Kelemen, et al., 2025); and digital nature**,** defined as technologically mediated representations of natural environments (e.g., videos, apps, Virtual or Augmented Reality) (Kim, et al., 2025). However, in this latter case, it is important to clarify that many authors argue that although the natural environment can be represented in the digital realm, it cannot replace it, since, to date, it does not engage all of our senses in the way that nature itself does (Gutiérrez-Pérez et al., 2024a, 2024b).

Different forms of children's engagement with nature

Although the literature has reported the importance of engaging with nature in childhood – not only for cognitive and emotional development, but also for fostering biophilia and environmental awareness (e.g., Aminpour, 2021; Arola et al., 2023; Thorsteinsson et al., 2023; Yeong Choe and Sheffield, 2024), the truth is that new generations are increasingly growing up in a way that is further detached from the natural environment. What's more, their reduced contact with nature not only has ramifications for their personal development, as it also affects children's relationship with the environment itself (Corrochano et al., 2025). Recent studies suggest that the less children are exposed to nature, the more their engagement with it tends to decrease with age, following a similar pattern across western countries, such as the UK (Hughes et al., 2019), Germany (Liefländer et al., 2013), and Canada (Crawford et al., 2017). This aspect in turn compromises their predisposition towards conserva-

tion (Chiesi et al., 2024). Nevertheless, Aminpour (2021) reports that children aged eight and nine use natural environments more often and in more ways than older children, which suggests that this stage of primary education is crucial for strengthening the link with nature (Chiumento et al., 2018; Larson et al., 2019).

Nonetheless, age is not the only factor that seems to play a crucial role in the relationship and engagement with nature, as there are also studies that have found significant differences in the way children interact with the natural environment. Although Serrate-González et al. (2025) have reported that girls say they enjoy nature more than boys, they appear to do so in a more controlled or less disinhibited manner. It comes as no surprise that some scholars find that boys have a more utilitarian approach to the way they engage with nature, simply for play and pleasure, recording lower values regarding the care and preservation of the natural environment (Bezeljak et al., 2023; Olssen & Gericke, 2017). In this respect, Tilstra et al. (2022) have found that boys tend to take part in activities that entail greater risk and adventure, which has meant that Outdoor Adventure Education appeals more to them. By contrast, girls are more likely to pursue activities in nature in a more controlled and risk-free manner. Although this is true, it is worth mentioning studies that have confirmed that when given the opportunity girls may behave in a way that is traditionally considered masculine in natural settings, which evidences that gender differences in the use of nature are informed by sociocultural factors and not innate predispositions (Abigail & Morrison, 2021). Some studies along these lines suggest that natural settings may promote gender equality by providing an environment that is devoid of the roles traditionally imposed (Änggård, 2011; Decker & Morrison, 2023), as opposed to others that indicate that the discriminant use of these spaces may reinforce gender stereotypes, restricting girls' involvement in outdoor activities involving exploration and leadership (Bryce et al., 2024; Novella-Cámara et al., 2021; Saldaña Blasco, 2018). This may undoubtedly be due to the fact that education in nature has historically focused on promoting masculine values (Bryce et al., 2024).

Regardless of which studies are more accurate in their conclusions, what both sets of research clearly demonstrate is that children's relationship with nature is always culturally mediated. For this reason, it is worth distinguishing between a ludic approach and a didactic approach to nature. We understand ludic experiences as spontaneous, open-ended, and intrinsically motivated interactions with natural elements, characterized by autonomy and exploration. In contrast, didactic experiences involve structured, adult-guided, or curriculum-based activities such as school gardens or guided observation. Although free access to natural environments has been shown to influence the quality of children's play (Antink-Meyer et al., 2026), given the inevitable cultural mediation and the potential biases that may accompany it, it is essential to promote didactic approaches that help minimize these biases. As Leisure Studies have shown, introducing a conscious pedagogical perspective into any human activity makes such activities more just, inclusive, and respectful of human dignity (Dattilo, 2021). This also aligns with recents contributions in outdoor and environmental education, which emphasise that intentional pedagogical design is crucial to ensuring that both digital technologies and natural environments are used in ways that promote equity, inclusion, and meaningful learning, rather than reinforcing existing social or gendered inequalities (Beames & Maher, 2024; Caballero-Julia et al., 2025).

In short, the literature reports a transformation in the relationship between natural and artificial scenarios in modern childhood, where hyperconnectivity and a nature deficit have altered the dynamics of development, socialisation, and learning. The relationship with technology and nature is mediated not just by individual factors but also by sociocultural aspects such as gender and age. These tendencies pose challenges of a pedagogical nature, stressing the need to promote strategies that strike a balance between access to technology and engagement with nature, thereby ensuring holistic and sustainable development in childhood. We therefore agree with Serrate-González et al. (2025) that it is essential to design and implement classroom practices that enable us to combine the digital and natural worlds. This will allow restoring the link between childhood and nature, without forgetting that digital technology is here to stay (Díaz-Romanillos, 2024).

Hypotheses of the study

Based on empirical evidence and current theories, the following hypotheses were proposed to guide the analysis; each hypothesis follows the expected results of previous studies on children's relationship with nature and technology, taking into account the possible influence of gender, school year and age.

H1. *There are significant gender-related differences regarding children's engagement with and use of nature and technology.* The literature indicates that girls tend to feel more connected to and derive greater enjoyment from nature (Serrate-González et al., 2025), whereas boys often display more utilitarian or risk-oriented behaviours in natural environments (Bezeljak et al., 2023; Tilstra et al., 2022). Sociocultural factors further shape the ways in which children participate in natural spaces (Novella-Cámara et al., 2021; Bryce et al., 2024; Abigail & Morrison, 2021).

H2. *There are significant school year-related differences regarding children's engagement with and use of nature and technology.* Research demonstrates that developmental changes in autonomy and cognitive maturity influence children's engagement with natural environments (Hughes et al., 2019; Aminpour, 2021; Arola et al., 2023). A demonstrable decline in natural connectivity transpires with the progression of education (Larson et al., 2019; Liefländer et al., 2013), coinciding with an escalation in digital exposure and technological engagement as individuals age (Smahel et al., 2020). These results confirm the expectation of differences between academic years.

H3. *There are significant age-related differences regarding children's engagement with and use of nature and technology.* Evidence demonstrates that connection to nature decreases with age (Crawford et al., 2017; Liefländer et al., 2013; Hughes et al., 2019), while younger children tend to use natural settings more frequently and in more varied ways (Aminpour, 2021). Conversely, older children exhibit greater digital involvement due to increased access to and use of technology (Smahel et al., 2020). These developmental trajectories justify expecting differences across age groups.

These assumptions together make up the analytical framework that guides the next steps in the research process.

Method

This is a quantitative, non-experimental, and cross-sectional study that adopts an exploratory-descriptive and correlational approach (Hernández et al., 2014). An analysis has been conducted of the range of perceptions among children aged between 9 and 13 regarding the variables affecting their links to technology and nature and the uses, both ludic and didactic, they make of them from the perspective of individual and social self-concept. The aim is to understand the influence they exert on childhood development and its immediate context, without interfering with the participants' natural conditions. This non-invasive approach guarantees the gathering of data that are representative of the cohort's everyday reality, thereby strengthening the research's ecological validity.

Population and sample

Stratified multistage sampling (Hernández et al., 2006; Hund et al., 2015) was applied to children aged between 9 and 13 in the last two years of primary education during the 2023–2024 school year, with a total population of 2,783,606 pupils (Spain's Ministry of Education and Occupational Training, 2023). Spain's self-governing regions, the *Comunidades Autónomas*, were grouped into four geographical areas: Centre, Northwest, East [*Levante*], and South. Forty-three schools were selected according to their location (rural or urban), socioeconomic position (low. medium, or high) and ownership (public or private grant-maintained [*concertado*]). Criteria of location, age, and gender were then applied and the sample was reduced to 2,586 children. The sampling error was ± 1.93% with a confidence level of 95.5%. The sample's final composition was as follows: a) Gender: 48.1% girls (n = 1,244), 49.7% boys (n = 1,286), 1.9% non-specific (n = 50); b) School year: 46.9% in Year 5 of primary (n = 1213), 53.1% in Year 6 (n = 1373); c) Age (M = 10.8 years, SD = 0.74): 0.5% aged 9 (n = 13), 30.3% aged 10 (n = 783), 47% aged 11 (n = 1222), 17.8% aged 12 (n = 460), and 1.3% aged 13 (n = 34); and d) Urbanisation (DEGURBA): 50.9% cities (n = 1316), 36.3% towns and suburbs (n = 940), and 12.8% rural (n = 330).

Instrument

From the perspective of a child's holistic and sustainable development, it is assumed that in late childhood (ages 9–13), too much technology (surplus) and a lack of contact with nature (deficit) affect key aspects of identity, such as a child's perception of their own self, autonomy, and critical thinking (Muñoz, 2021). The variables were operationalised in collaboration with research teams on the NATEC-ID project, in keeping with the study's objectives. The categorical variables were age, gender, school year, and location, while the four dimensions (engagement, didactic use, ludic use, and parental control) were divided into two blocks: nature and technology. Finally, a structured, anonymous, and self-administered 32-item questionnaire was

drawn up on paper, involving an eleven-point Likert scale (0–10 points) (Bisquerra & Pérez-Escoda, 2015). The following is an example of one of the items: "When I am outdoors: (0 I want to go home; 10 I don't want to go home)". The questionnaire was subject to a trial run with 15 schoolchildren aged 9–11 for detecting any errors and estimating the time required for its completion, which led to the tweaking of the draft, its structure, and the addition of explanatory instructions.

Procedure

The field-work was held at several schools from January to April 2024, with prior permission from its leaders, teachers, and parents and guardians. The questionnaires were administered in the classrooms, following the same protocol: the children were given a clear, straightforward explanation of the research's aims, stressing the voluntary and valuable nature of their participation; the general instructions were read out and any questions were answered; in addition, individual support was provided for any pupils with special education needs. The self-administered questionnaire took around 20 min to complete, which guaranteed a uniform process that upheld the ethical principles of research involving children.

Data analysis

Microsoft Excel was used to log and process the data, and IBM SPSS Statistics v28 software was used for the statistical analysis. The analysis involved 24 items from the questionnaire, corresponding to three dimensions (engagement, didactic use, and ludic use) from each block. The questionnaire's internal consistency, appraised with Cronbach's alpha, revealed variations between the dimensions studied: engagement with nature (5 items, $\alpha = 0.689$); didactic use of nature (3 items, $\alpha = 0.524$); ludic use of nature (3 items, $\alpha = 0.512$); engagement with technology (5 items, $\alpha = 0.737$); didactic use of technology (4 items, $\alpha = 0.572$); and ludic use of technology (4 items, $\alpha = 0.520$). Although some of the dimensions recorded a low internal consistency, possibly due to the small number of items, these figures may be considered acceptable for an exploratory study (Merino & Lautenschlager, 2003).

The Kolmogorov–Smirnov test produced $p < 0.05$ across all dimensions, validating that the data did not conform to a normal distribution and facilitating the application of non-parametric statistics (Razali & Wah, 2011). Consequently, the median served as the primary measure of central tendency because of its resilience to skewed distributions and outliers. Means and standard deviations are given only for descriptive purposes, as is recommended for openness in social and educational research. Following the preliminary descriptive analysis of frequencies and measures of central tendency, non-parametric tests were employed to examine group differences. We used the Mann–Whitney U test to compare two independent groups that were not related based on gender and school year. The Kruskal–Wallis test was applied to analyse differences among age groups, as it is suitable for comparing multiple groups without the assuming normality. When significant effects were identified, pairwise comparisons were conducted using Bonferroni adjustments to control for Type I error in multiple comparisons.

Results

Regarding the descriptive analysis of the variables according to gender The results reveal subtle yet significant differences between boys and girls in terms of their engagement with and use of nature and technology. Girls are more engaged with nature (M = 3.38, SD = 0.691) than boys (M = 3.24, SD = 0.742). In turn, boys engage more with technology (M = 3.34, SD = 0.712) than girls (M = 3.03, SD = 0.706). As regards ludic use, boys tend to use nature more (M = 3.28, SD = 0.720) than girls (M = 3.18, SD = 0.690), while girls make greater ludic use of technology (M = 3.33, SD = 0.741) than boys (M = 3.19, SD = 0.792). The didactic use of nature and technology differs only slightly between boys and girls, with consistent means of 3.00 for all the variables, which indicates a balanced distribution between both groups (Table 1).

H1. There are significant gender-related differences regarding children's engagement with and use of nature and technology.

The Mann–Whitney U test was used to verify the differentiation and heterogeneity of the responses provided by these two groups, considering a 0.05 significance level. As regards *engagement with nature*, the data revealed significant statistical differences between girls and boys ($p < 0.001$), reflecting major disparities in their perceptions. Likewise, *engagement with technology* recorded significant differences according to gender ($p = 0.000$). The *ludic use* of both nature ($p < 0.001$) and technology ($p < 0.001$) revealed significantly different patterns, suggesting that recreational activities in both cases are perceived and enjoyed differently. In turn, the results for *didactic use* recorded significant differences for nature ($p = 0.040$), albeit to a lesser degree, while no such differences were found in the case of technology ($p = 0.492$), which suggests greater uniformity in this aspect (see Table 2).

Descriptive analysis of the variables according to school year The figures reveal subtle yet interesting differences between the children in Years 5 and 6. Pupils in Year 5 record a slightly greater engagement with nature (M = 3.36, SD = 0.718) than those in Year 6 (M = 3.26, SD = 0.730). However, this tendency is reversed in engagement

Table 1 Descriptive statistics gender-variables

Variables	Gender	M	SD	Mdn
Engagement with nature	Girl	3.38	0.691	3.00
	Boy	3.24	0.742	3.00
Engagement with technology	Girl	3.03	0.706	3.00
	Boy	3.34	0.712	3.00
Ludic use of nature	Girl	3.18	0.690	3.00
	Boy	3.28	0.720	3.00
Didactic use of nature	Girl	2.70	0.663	3.00
	Boy	2.64	0.732	3.00
Ludic use of technology	Girl	3.33	0.741	3.00
	Boy	3.19	0.792	3.00
Didactic use of technology	Girl	3.26	0.763	3.00
	Boy	3.26	0.800	3.00

Girls $n = 1{,}244$; boys $n = 1{,}286$. The responses: Very low engagement 1; Low engagement 2; High engagement 3; Very high engagement 4

Table 2 Statistical differences between genders

Variable	U-statistic	Z	*p*-value
Engagement with nature	710974.500	−4.623	<0.001
Engagement with technology	718893.500	−11.391	0.000
Ludic use of nature	729159.000	−3.532	<0.001
Didactic use of nature	668978.000	−2.056	0.040
Didactic use of technology	682580.500	−0.687	0.492
Ludic use of technology	649933.000	−4.598	<0.001

The Mann–Whitney U test was used to compare girls and boys. Statistical significance was set at $p<0.05$

with technology, where Year 6 pupils record a higher mean (M = 3.24, SD = 0.703) than those in Year 5 (M = 3.13, SD = 0.755). In terms of the ludic and didactic use of nature, both years record similar figures, with a slight advantage for Year 5. By contrast, Year 6 pupils report a greater use of technology for ludic (M = 3.32, SD = 0.742) and didactic (M = 3.31, SD = 0.739) purposes than those in Year 5, indicating increased familiarity of use in older pupils. (See Table 3).

Figure 1 presents gender differences across all study dimensions. Girls show higher engagement with nature and higher ludic use of technology, whereas boys report higher engagement with technology and higher ludic use of nature. Didactic uses display minimal variation between genders, supporting the statistical results previously reported.

H2. There are significant school year-related differences regarding children's engagement with and use of nature and technology.

The Mann–Whitney U test was again used to study the differences and heterogeneity between these two groups, and it revealed significant differences in several dimensions. Engagement with nature ($p<0.001$) and with technology ($p<0.001$) differ significantly between the years. Likewise, the didactic use of nature ($p<0.001$) and of technology ($p=0.024$) also record significant differences, which suggests that the inclusion of these resources in the learning process is perceived differently from one year to the next. In turn, the ludic use of technology ($p<0.001$) recorded a considerable variation between years, whereas the ludic use of nature ($p=0.142$) did not record any significant differences, which indicates a uniform experience in recreational, outdoor pursuits (see Table 4).

Table 3 Descriptive statistics school year-variables

Variables	Year	M	SD	Mdn
Engagement with nature	5	3.36	0.718	3.00
	6	3.26	0.730	3.00
Engagement with technology	5	3.13	0.755	3.00
	6	3.24	0.703	3.00
Ludic use of nature	5	3.25	0.698	3.00
	6	3.21	0.719	3.00
Didactic use of nature	5	2.72	0.717	3.00
	6	2.64	0.684	3.00
Ludic use of technology	5	3.18	0.806	3.00
	6	3.32	0.742	3.00
Didactic use of technology	5	3.20	0.831	3.00
	6	3.31	0.739	3.00

Year 5 $n=1,213$; Year 6 $n=1,373$. The responses: Very low engagement 1; Low engagement 2; High engagement 3; Very high engagement 4

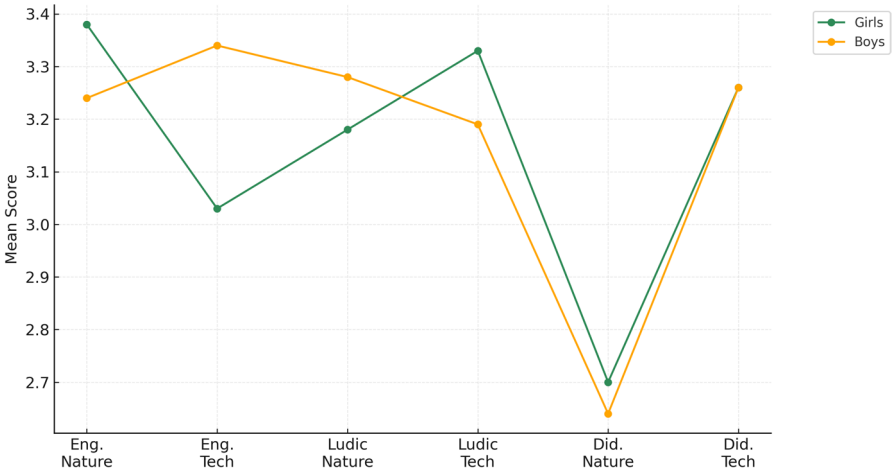

Fig. 1 Gender differences in children's engagement and use of nature and technology

Table 4 Statistical differences between Years 5 and 6

Variable	U-statistic	Z	*p*-value
Engagement with nature	710974.500	−3.561	<0.001
Engagement with technology	718893.500	−3.302	<0.001
Ludic use of nature	729159.000	−1.467	0.142
Didactic use of nature	668978.000	−4.192	<0.001
Didactic use of technology	682580.500	−2.253	0.024
Ludic use of technology	649933.000	−4.366	<0.001

The Mann–Whitney U test was used to compare Years 5 and 6. Statistical significance was set at $p<0.05$

The children's age An analysis of the data reveals significant age-related tendencies in the pupil's relationship with nature and technology. Engagement with nature records a slight drop with age, peaking among 10-year-olds (M=3.36, SD=0.720) and then decreasing to its lowest point in 13-year-olds (M=3.00, SD=0.707). By contrast, engagement with technology records more stable figures, peaking among 12 year-olds (M=3.29, SD=0.688). The ludic use of nature decreases sharply with age, from a high point among 9-year-olds (M=3.60, SD=0.516) to a low point among 13 year-olds (M=3.04, SD=0.676). In turn, the ludic and didactic use of technology follows a rising trend, peaking among 13-year-olds (M=3.40, SD=0.763 and M=3.44, SD=0.768, respectively) (see Table 5).

Figure 2 summarises the differences between Year 5 and Year 6 pupils. Year 5 pupils show slightly higher engagement with nature, whereas Year 6 pupils demonstrate higher engagement with technology and greater ludic and didactic use of technological tools. These patterns visually complement the statistical results reported above.

H3. There are significant age-related differences regarding children's engagement with and use of nature and technology.

Table 5 Descriptive differences age-variables

Variables	Age (in years)	M	SD	Mdn
Engagement with nature	9	3.30	0.823	3.00
	10	3.36	0.720	3.00
	11	3.30	0.707	3.00
	12	3.22	0.779	3.00
	13	3.00	0.707	3.00
Engagement with technology	9	3.20	1.033	3.00
	10	3.13	0.725	3.00
	11	3.18	0.741	3.00
	12	3.29	0.688	3.00
	13	3.16	0.688	3.00
Ludic use of nature	9	3.60	0.516	3.00
	10	3.23	0.719	3.00
	11	3.23	0.690	3.00
	12	3.18	0.762	3.00
	13	3.04	0.676	3.00
Didactic use of nature	9	3.00	0.816	3.00
	10	2.70	0.709	3.00
	11	2.66	0.688	3.00
	12	2.62	0.704	3.00
	13	2.76	0.723	3.00
Ludic use of technology	9	3.10	1.286	3.00
	10	3.17	0.809	3.00
	11	3.27	0.766	3.00
	12	3.37	0.723	3.00
	13	3.40	0.763	3.00
Didactic use of technology	9	3.10	1.197	3.00
	10	3.17	0.830	3.00
	11	3.27	0.764	3.00
	12	3.34	0.739	3.00
	13	3.44	0.768	3.00

9-year-olds $n=13$; 10-year-olds $n=783$; 11-year olds $n=1{,}222$; 12-year-olds $n=460$; 13-year-olds $n=34$. The responses: Very low engagement 1; Low engagement 2; High engagement 3; Very high engagement 4

The results of the Kruskal–Wallis analysis show significant differences between the age groups in several dimensions related to the use of nature and technology. Specifically, statistically significant differences were found in the ludic use of technology ($p=0.003$), the didactic use of technology ($p=0.029$), the didactic use of nature ($p=0.038$), engagement with technology ($p=0.005$), and engagement with nature ($p=0.005$). Subsequent pairwise comparisons indicate that these differences are more acute between certain age groups. For example, engagement with technology records significant differences between 10- and 12-year-old boys (H = −138.819; adjusted $p=0.003$), with those aged 12 being more engaged. Engagement with nature recorded a significant difference between 10- and 12-year-old boys (H = 118.736; adjusted p = 0.019), with those aged 12 also being more engaged. The ludic use of technology recorded a significant difference between 10- and 12-year-old boys (H = −142.866; adjusted $p=0.002$), and here, too, those aged 12 reported a greater use. The didactic use of technology also recorded a significant difference between these two age groups (H = −116–332; adjusted $p=0.022$) (See Table 6).

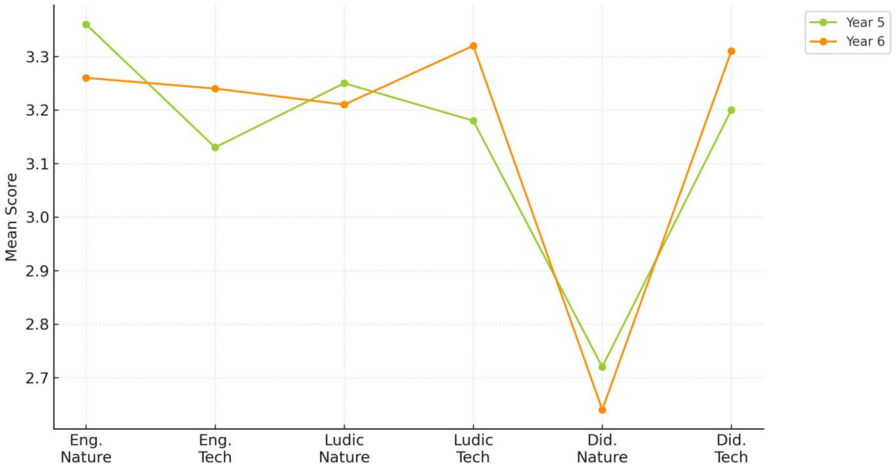

Fig. 2 Differences between Year 5 and Year 6 pupils in engagement and use of nature and technology

Table 6 Statistical differences between age groups

Variables	X^2	df	*p*	Significant pairwise comparisons
Engagement with nature	14.965	4	0.005	Ages 10 - 12 (Sig. adjusted $p=0.019$)
Engagement with technology	14.726	4	0.005	Ages 10 - 12 (Sig. adjusted $p=0.003$)
Ludic use of nature	3.884	4	0.422	Overall sig. adjusted $p=1.000$ - Non-sig
Ludic use of technology	16.049	4	0.003	Ages 10 - 12 (Sig. adjusted $p=0.002$)
Didactic use of technology	10.797	4	0.029	Ages 10 - 12 (Sig. adjusted $p=0.022$)
Didactic use of nature	10.129	4	0.038	Ages 10 - 12 (Sig. adjusted $p=0.050$)

Significant pairwise comparisons following a Bonferroni adjustment. $\chi 2$ = Kruskal–Wallis statistic; df = degree of freedom; p = significance level

Figure 3 provides an overview of age-related trends, showing that people are increasingly disconnected from nature and make greater use of technology. It summarizes the developmental trajectories identified in the statistical analyses, with a progression toward more digitized activities during preadolescence.

Discussion and conclusions

The literature reports the importance of children's engagement with nature on a personal level (identity, development, health) and for biophilia (caring for the planet, respect for animals, the fight against climate change, for example). Furthermore, the literature also finds differences in both age (importance of spending time outdoors from an early age) and gender (the way boys and girls use and enjoy nature). Nevertheless, we cannot ignore the presence of digital technology in our lives both now and

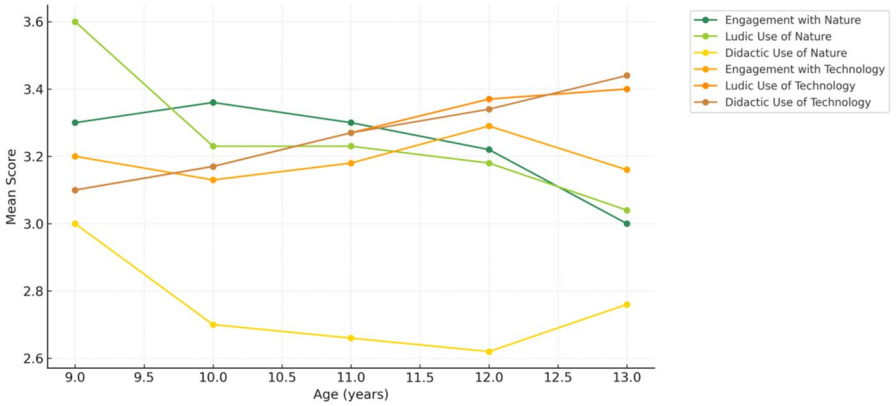

Fig. 3 Age-related differences in children's engagement and use of nature and technology

in the future. Along these lines, our study provides evidence that can be considered for the design of teaching practices in childhood.

Firstly, the descriptive analysis of the variables according to gender suggests that girls tend to feel more engaged with nature, while boys are more interested in technology; this notion is consistent with prior studies (Bezeljak et al., 2023; Olssen & Gericke, 2017). The results for H1 show that gender does influence childhood experiences with nature and technology, especially in play contexts. Girls felt more connected to nature, boys to technology. Additionally, boys reported using nature more for play, while girls used technology more, revealing clear gender-based patterns in play behaviour. However, the differences found in pedagogical uses were minimal or nonexistent, indicating that school contexts generate more uniform patterns between boys and girls. These findings are consistent with previous research on gender differences in outdoor play, affective connection to nature, and technology use (Serrate-González et al., 2025; Bezeljak et al., 2023; Tilstra et al., 2022; Bryce et al., 2024; Novella-Cámara et al., 2021).These findings reveal that there is room to incorporate nature into educational practices, given the connection that both boys and girls feel with it; in other words, nature is underused didactically and would likely be well received by students.

Secondly, the data analysis revealed a significant change in the way the children interacted with nature and technology during the final stages of primary education. The results for H2 show that the school year makes a substantial difference in these interactions. Fifth graders felt more connected to nature, whereas Year 6 students reported a stronger engagement with technology. Sixth-grade pupils also demonstrated higher recreational and educational use of digital tools, while Year 5 students performed slightly better in the educational use of nature. These results suggest an evolution as students approach the end of primary school, characterised by greater autonomy, increased exposure to digital resources and rising academic demands. These findings align with previous research documenting a decline in nature connectedness as schooling progresses (Larson et al., 2019; Liefländer et al., 2013) and increased technological engagement with age (Smahel et al., 2020). Overall, these

results emphasise the need to consider school progression when designing learning environments that integrate both nature and technology.

Thirdly, and in keeping with the previous conclusion, the data also reveal a gradual change in the children's interests and habits as they grow older. Again, this is consistent with prior studies (Crawford et al., 2017; Hughes et al., 2019; Liefländer et al., 2013). This means that age has a key role to play in the way boys interact with nature and technology in both ludic and didactic contexts. This may have significant implications for the design of classroom and recreational activities adapted to different age groups. It is particularly interesting to observe that engagement with nature increases significantly between the ages of 10 and 12, which indicates that the development of the relationship with nature is not necessarily compromised by a greater use of technology. This may be due to factors such as children's gradual acquisition of autonomy in the use of their leisure time or their exposure to dynamics of social digitalisation. We therefore agree with Chiumento et al. (2018) and Larson et al. (2019) that childhood is a crucial time for developing educational practices that foster an engagement with nature.

In addition, the results for H3 also show a clear age-related trend in the opposite direction for technology. While engagement with nature decreases from ages 10 to 13, recreational and educational uses of technology increase linearly, and engagement with technology remains stable or even rises slightly around age 12. This suggests a gradual shift in children's preferences during preadolescence, characterised by greater digital immersion and reduced outdoor engagement. These developmental patterns are consistent with previous research indicating a decline in nature connectedness with age and an increase in digital involvement as children grow older (Smahel et al., 2020). Taken together, these findings underscore the need for pedagogical approaches tailored to different developmental stages to sustain children's relationship with nature in an increasingly digitalised world.

A more hermeneutic reading of didactic and ludic uses prompts a number of interesting insights. In terms of didactic use, there is an assumption that schooling has a homogenising effect on children's relationship with nature and technology. An analysis of the didactic uses of nature and technology according to gender does not find any significant differences, as instead the disparities are between school years, reflecting the importance of these contexts as learning resources. We may therefore reflect upon the question of whether schools are turning their backs on nature. This renders it expedient to study the role played by teachers' training and professional development –and their relationship with nature and technology- in the pursuit of teaching–learning processes (Corrochano et al., 2025). This focus on teachers may provide a further angle to supplement the ones presented here. In addition, another future line of research could address curricular aspects by analysing both the content related to the presence of nature and technology (Guardeño & Monsalve, 2023) -potentially attributing part of the responsibility to the design and development of the syllabus at this stage- and the role that active methodologies might play in a greater didactic use of nature for working on core competencies.

In terms of ludic use, the differences reflect a decrease in the ludic use of nature with age (and school year). This is consistent with the study's epistemological framework based on the premise that childhood is impacted by a process of hyperconnec-

tivity (which may be an effect of children's overexposure to the digital ecosystem). Reducing children's digital exposure might lead to greater engagement with nature. This is a conclusion that might be supported by our results, which have shown that a reduced ludic use of nature goes hand-in-hand with a lower engagement with it.

At this point, it is also important to acknowledge several methodological considerations that frame the scope of these findings: a) since this was a cross-sectional design, the results represent a specific snapshot of the phenomenon, and longitudinal studies would be appropriate to analyse its evolution; b) although the sample is large and varied, participation was contingent on the voluntary collaboration of the centres, which could lead to an under-representation of certain educational contexts; c) contextual variables such as family resources, the availability of natural spaces, and access to technology at home were omitted; these elements should be considered in future research to achieve a deeper understanding of the factors influencing children's experiences.

In sum, to avoid losing our way in the digital forest we should rethink the relationship between childhood and screens and nature. This redefinition directly involves the education system, calling upon schools to redefine their role in response to the exponential growth of social digitalisation (Monarca et al., 2025) processes and requiring teachers to adopt a critical and responsible attitude towards such processes. This task brings together and calls upon teachers (training focused on the benefits of nature for knowledge acquisition), researchers (analyses of the relationships between schools, teachers, families, and nature), and professionals (on the one hand, incorporating a pedagogical lens into the design of playful and educational digital products, and on the other, increasing the presence of environmental education in the official curriculum). The redefinition we refer to must take into account the risks posed by digital artifacts in the construction of children's subjectivity (Sánchez-Rojo et al., 2022; Muñoz, 2021) as well as the benefits provided by early interactions with nature (Chawla, 2020). Schools, families, the media, technology companies, and policymakers must consider the pedagogical perspective when integrating children into nature so that this educational, pedagogical, and cultural practice is as equitable and fair as possible in socio-economic and gender terms.

In conclusion, and from a broader perspective, it is essential to emphasise the need to critically integrate mobile technologies into outdoor learning experiences, rather than positioning them as opposing forces. Such approaches highlight the central role of pedagogy in mediating children's relationships with both nature and digital media within increasingly hybrid educational landscapes (Beames & Maher, 2024).

Acknowledgements This work was supported by "NATEC-ID. Analysis of the processes of (dis-re) connection with NAture and TEchnology when building a child's Identity" funded by Spain's Ministry of Science and Innovation (PID 2021-122993NB-100), and "Disruptive technology as a catalyst for the ecological transition from environmental education. Study and design of techno-educational solutions from NaturTEC Kids livinglab." funded by Spain's Ministry of Science and Innovation (TED 2021-130300A-C22).

Author Contributions Judith Martín, Gabriel Álvarez and Alberto Sánchez wrote the main manuscript text, Rosalynn Campos. works and wrote the analysis and interpretation of data. All authors reviewed the manuscript.

Funding Open access funding provided by FEDER European Funds and the Junta de Castilla y León under the Research and Innovation Strategy for Smart Specialization (RIS3) of Castilla y León 2021-2027. Open access publishing has been supported by the University of Salamanca withing the framework of the CRUE-CSIC transformative agreements. Also, this research was supported by "NATEC-ID. Analysis of the processes of (dis-re) connection with NAture and TEchnology when building a child's Identity" funded by Spain's Ministry of Science and Innovation (PID 2021-122993NB-100), and "Disruptive technology as a catalyst for the ecological transition from environmental education. Study and design of techno-educational solutions from NaturTEC Kids livinglab." funded by Spain's Ministry of Science and Innovation (TED 2021-130300A-C22).

Data availability No datasets were generated or analysed during the current study.

Declarations

Ethical approval The study was approved by the Ethics Committee of University of Salamanca.

Consent to participate and publication The author gives consent to publish the article. There is no conflict of interest to declare related to this work. The order of authorship has been agreed upon by all authors.

Human ethics Participants' confidentiality and anonymity were fully protected throughout the research process, and the authors obtained informed consent for the publication of anonymised data including from all participants and their parents and caregivers involved in the study.

Competing interests The authors declare no competing interests.

References

Abigail, D., & Morrison, S. A. (2021). Decoding gender in nature-based education: Perceptions of environmental educators. *Environmental Education Research, 27*(6), 848–863. https://doi.org/10.1080/13504622.2021.1898548

Aminpour, F. (2021). The physical characteristics of children's preferred natural settings in Australian primary school grounds. *Urban Forestry & Urban Greening*. https://doi.org/10.1016/j.ufug.2021.127163

Anitha, F. S., Narisimhan, U., Janakiraman, A., Janakarajan, N., & Tamilselvan, P. (2021). Association of digital media exposure and addiction with child development and behavior. A cross-sectional study. *Industrial Psychiatry Journal, 30*(2), 265–271. https://doi.org/10.4103/ipj.ipj_157_20

Antink-Meyer, A., Lorsbach, A. W., & Brown, R. A. (2026). Children's nature play: Access to the outdoors and interactions with biodiversity. *Journal of Adventure Education and Outdoor Learning*, *26*(1), 32–48. https://doi.org/10.1080/14729679.2024.2420316

Arola, T., Aulake, M., Ott, A., Lindholm, M., Kouvonen, P., Virtanen, P., & Paloniemi, R. (2023). The impacts of nature connectedness on children's well-being: Systematic literature review. *Journal of Environmental Psychology, 85*, Article 101913. https://doi.org/10.1016/j.jenvp.2022.101913

Beames, S. K., & Maher, P. T. (2024). *Routledge handbook of mobile technology, social media and the outdoors* (1st ed). Routledge. https://doi.org/10.4324/9781003367536

Bezeljak, P., Torkar, G., & Möller, A. (2023). Understanding Austrian middle school students' connectedness with nature. *The Journal of Environmental Education, 54*(3), 181–198. https://doi.org/10.1080/00958964.2023.2188577

Bisquerra, R., & Pérez-Escoda, N. (2015). ¿Pueden las escalas likert aumentar en sensibilidad? *REIRE, Revista d'Innovació i Recerca en Educació, 8*(2), 129–147. https://doi.org/10.1344/reire2015.8.2828

Bryce, C. J. C., Dadswell, K., Dallat, C., & Parker, A. G. (2024). Perceptions of empowerment and leadership in the context of outdoor education: A qualitative study in women participants. *Journal of Outdoor and Environmental Education, 27*, 413–436. https://doi.org/10.1007/s42322-023-00136-2

Caballero, D., Martín-Lucas, J., & Andrade Silva, L. (2024). Unpacking the relationship between screen use and educational outcomes in childhood: A systematic literature review. *Computers & Education, 215*, Article 105049. https://doi.org/10.1016/j.compedu.2024.105049

Caballero-Julia, D., Herrarte-Prieto, L., Murciano-Hueso, A., & Parra-Nieto, G. (2025). Nature and technology connection profiles of the child population in Spain. *Social Sciences & Humanities Open, 11*, Article 101431. https://doi.org/10.1016/j.ssaho.2025.101431

Capaldi, C. A., Passmore, H. A., Nisbet, E. K., Zelenski, J. M., & Dopko, R. L. (2015). Flourishing in nature: A review of the benefits of connecting with nature and its applications as a wellbeing intervention. *International Journal of Wellbeing, 5*(4), 1–16. https://doi.org/10.5502/ijw.v5i4.449

Chawla, L. (2020). Childhood nature connection and constructive hope: A review of research on connecting with nature and coping with environmental loss. *People and Nature, 2*, 619–642. https://doi.org/10.1002/pan3.10128

Chiesi, L., Costa, P., Ciaravella, F., & Galmarini, B. (2024). Re-naturalizing the built environment. Plants, architecture, and pedagogy in contemporary green schools. *Frontiers in Sustainable Cities, 6*, Article 1397159. https://doi.org/10.3389/frsc.2024.1397159

Chiumento, A., Mukherjee, I., Chandna, J., Dutton, C., Rahman, A., & Bristow, K. (2018). A haven of green space: Learning from a pilot pre-post evaluation of a school-based social and therapeutic horticulture intervention with children. *BMC Public Health, 18*(1), Article 836. https://doi.org/10.1186/s12889-018-5661-9

Corrochano, D., Gómez-Gonçalves, A., Serrate, S., & Muñoz-Rodríguez, J. M. (2025). Connectedness to nature: Assessing the impact of garden-based learning on teacher education. *Journal of Outdoor and Environmental Education*. https://doi.org/10.1007/s42322-025-00201

Crawford, M. R., Holder, M. D., & O'Connor, B. P. (2017). Using mobile technology to engage children with nature. *Environment and Behavior*, *49*(9), 959–984. https://doi.org/10.1177/0013916516673870

Dattilo, J. (2021). *Leisure education program planning: A systematic approach*. Sagamore-Venture Publishing.

Díaz-Romanillos, E. (2024). Reimaginando la educación ambiental en la era del Antropoceno: Una reflexión ética. *Teoría De La Educación. Revista Interuniversitaria, 36*(2), 59–78. https://doi.org/10.14201/teri.31794

Decker, A. M., & Morrison, S. A. (2023). Are these girl ladybugs or boy ladybugs?": An exploratory study on gender in nature-based education. *Journal of Environmental Education, 54*(5), 325–340. https://doi.org/10.1080/00958964.2023.2241394

del Alonso Casar, J. (2025). Pedagogías salvajes: Nuevas concepciones para una ontología relacional en educación. *Teoría de la Educación. Revista Interuniversitaria, 37*(1), 45–63. https://doi.org/10.14201/teri.31881

Dewey, A. M. (2021). Shaping the environmental self: The role of childhood experiences in shaping identity standards of environmental behavior in adulthood. *Sociological Perspectives, 64*(4), 657–675. https://doi.org/10.1177/0731121420981681

Guardeño, M., & Monsalve, L. (2023). Desarrollo curricular de educación para el desarrollo sostenible en España, Finlandia e Irlanda. *Revista Iberoamericana De Investigación En Educación*, 7. https://doi.org/10.58663/riied.vi7.131

Guattari, F. (1999). *Les Trois Écologies*. Editorial Galilée.

Gutiérrez-Pérez, B. M., Ruedas-Caletrio, J., Caballero Franco, D., & Murciano-Hueso, A. (2024a). Connection with Nature as a key factor in the formation of childhood identities: A systematic review. *Teoría de la Educación. Revista Interuniversitaria, 36*(1), 31–52. https://doi.org/10.14201/teri.31397

Gutiérrez-Pérez, B. M., Silva-Fernánez, M. T., & Serrate González, S. (2024b). Open innovation: The experience of NaturTEC-Kids Living Lab in the co-design of a video game to engage children and adolescents with nature. *Educational Media International, 61*(4), 440–453. https://doi.org/10.1080/09523987.2024.2436763

Harverson, J., Paatsch, L., Anglim, J., & Horwood, S. (2025). Digital technology use and well-being in young children: A systematic review and meta-analysis. *Computers in Human Behavior*. https://doi.org/10.1016/j.chb.2025.108660

Hernández, R., Fernández-Collado, C., & Baptista, P. (2006). *Metodología de la Investigación* (4th ed). McGraw-Hill.

Hernández, R., Fernández, C., & Baptista, P. (2014). *Metodología de la investigación* (6ª ed). McGraw-Hill.

Hughes, J., Rogerson, M., Barton, J., & Bragg, R. (2019). Age and connection to nature: When is engagement critical? *Frontiers in Ecology and the Environment, 17*(5), 265–269. https://doi.org/10.1002/fee.2035

Hund, L., Bedrick, E. J., & Pagano, M. (2015). Choosing a cluster sampling design for lot quality assurance sampling surveys. *PLoS One*. https://doi.org/10.1371/journal.pone.0129564

Kelemen, E., Czett, K., & Szentendrey, R. (2025). School gardens as commons: Fostering relational values for biodiversity trough participatory environmental education. *International Journal of the Commons, 19*(1), 431–443. https://doi.org/10.5334/ijc.1539

Kilbey. (2017). *Unplugged parenting.* Headline Home.

Kim, J., Patel, S., Nam, H., Cho, J., & Kim, K. (2025). Experiencing immersive virtual nature for well-being, restoration, performance, and nature connectedness: A scoping review. *IEEE Transactions on Visualization and Computer Graphics*. https://doi.org/10.1109/TVCG.2025.3616762

Kimmerer, R. W. (2020). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Penguin Books.

Larson, L. R., Szczytko, R., Bowers, E. P., Stephens, L. E., Stevenson, K. T., & Floyd, M. F. (2019). Outdoor time, screen time, and connection to nature: Troubling trends among rural youth? *Environment and Behavior, 51*(8), 966–991. https://doi.org/10.1177/0013916518806686

Liefländer, A. K., Fröhlich, G., Bogner, F. X., & Schultz, P. W. (2013). Promoting connectedness with nature through environmental education. *Environmental Education Research, 19*(3), 370–384. https://doi.org/10.1080/13504622.2012.697545

Louv, R. (2008). *Last child in the woods. Saving our children from nature-deficit disorder.* Paperback.

Merino, C., & Lautenschlager, G. (2003). Comparación Estadística de la Confiabilidad Alfa de Cronbach: Aplicaciones en la Medición Educacional y Psicológica. *Revista de Psicología, 12*(2), 127–136. https://doi.org/10.5354/0719-0581.2003.17668

Millan Ghisleri, E., & Caro Samada, C. (2021). Prevention of cyberhate and cyberbullying in adolescents: Family strategies for personal growth. *Teoría de la Educación. Revista Interuniversitaria, 34*(1), 105–124. https://doi.org/10.14201/teri.26157

Ministerio de Educación y Formación Profesional [Spain's Ministry of Education and Occupational Training] (2023). Datos y cifras. Curso escolar 2023–2024 [Secretaría General Técnica]. Retrieved from: https://www.libreria.educacion.gob.es/libro/datos-y-cifras-curso-escolar-2023-2024_181742/

Monarca, H., Álvarez-López, G., & Rappoport, S. (2025). The role of schools in shaping the individuals and the world in the digital era. *Digital Education Review, 47*, 14–27. https://doi.org/10.1344/der.2025.47.14-27

Muñoz, J. M. (2021). *Identity in a hyperconnected society. Risks and educative proposals*. Springer Nature. https://doi.org/10.1007/978-3-030-85788-2

Änggård, E. (2011). Children's gendered and non-gendered play in natural spaces. *Children, Youth and Environments, 21*(2), 5–33.

Novella-Cámara, A., Romero-Pérez, C., Melero, H., & Noguera-Pigem, E. (2021). Participación infantil, política local y entorno digital: Visiones y usos en municipios españoles. *Comunicar, 69*, 33–43. https://doi.org/10.3916/C69-2021-03

Olssen, D., & Gericke, N. (2017). The effect of gender on students' sustainability consciousness: A nationwide Swedish study. *The Journal of Environmental Education, 48*(5), 357–370. https://doi.org/10.1080/00958964.2017.1310083

Otrel-Cass, K. (2022). Presenting a students' tale: The smartphone manifesto. *International Journal of Educational Research, 114*, Article 101999. https://doi.org/10.1016/j.ijer.2022.101999

Razali, N., & Wah, Y. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. *Journal of Statistical Modeling and Analytics, 2*, 21–33.

Saldaña Blasco, D. (2018). Reorganizar el patio de la escuela, un proceso colectivo para la transformación social. *Hábitat Y Sociedad*, 11. https://doi.org/10.12795/HabitatySociedad.2018.i11.11

Sánchez-Rojo, A., García del Dujo, Á., Muñoz-Rodríguez, J. M., et al. (2022). Grammars of "onlife" identities: Educational re-significations. *Studies in Philosophy and Education*, *41*, 3–19. https://doi.org/10.1007/s11217-021-09811-7

Selden, S. (2024). I wonder what they *do* teach them in these schools: *The chronicles of Narnia* and nature-deficit disorder. *Children's Literature in Education, 55*, 449–464. https://doi.org/10.1007/s10583-022-09515-7

Serrate-González, S., Alonso-del-Casar, J., Patino-Alonso, C., & Muñoz-Rodríguez, J. M. (2025). Déficit de naturaleza y sobreuso de tecnología en la infancia. Un estudio correlacional por género sobre la influencia en la construcción identitaria sostenible de la infancia [Nature deficit and technology overuse in childhood. A correlational study by gender of its influence on sustainable identity construction in childhood]. *Revista Española de Pedagogía, 83*(290), 141–157. https://doi.org/10.22550/2174-0909.4124

Smahel, D., Machackova, H., Mascheroni, G., Dedkova, L., Staksrud, E., Ólafsson, K., Livingstone, S., & Hasebrink, U. (2020). *EU Kids online 2020: survey results from 19 countries.* EU kids online. https://doi.org/10.21953/lse.47fdeqj01ofo

Stiegler, B. (1998). *Technics and time, 1: The fault of Epimetheus*. Stanford University Press.

Stripe. N. (2020). Children's online behaviour in England and Wales: year ending March 2020. *UK office for national statistics.* Retrieved from: https://www.ons.gov.uk/peoplepopulationandcommunity/crimeandjustice/bulletins/childrensonlinebehaviourinenglandandwales/yearendingmarch2020

Thorsteinsson, J. F., Arnarsson, Á., & Jónasson, J. T. (2023). How 'outdoors time' transforms the social relationships of children in Iceland. *Journal of Outdoor and Environmental Education, 26*, 227–246. https://doi.org/10.1007/s42322-023-00123-7

Tilstra, E., Magnuson, D., Harper, N. J., et al. (2022). Gender and risk in outdoor adventure education. *Journal of Outdoor and Environmental Education, 25*, 181–197. https://doi.org/10.1007/s42322-022-00098-x

Torrijos-Fincias, P., Serrate-González, S., Martín-Lucas, J., & Muñoz-Rodríguez, J. M. (2021). Perception of risk in the use of technologies and social media. Implications for identity building during adolescence. *Education Sciences, 11*(9), Article 523. https://doi.org/10.3390/educsci11090523

Wilson, E. O. (1984). *Biophilia*. Harvard University Press.

Yau, J. C., & Reich, S. M. (2019). It's just a lot of work": Adolescents' self-presentation norms and practices on Facebook and Instagram. *Journal of Research on Adolescence, 29*(1), 196–209. https://doi.org/10.1111/jora.12376

Yeong Choe, E., & Sheffield, D. (2024). Rebuilding human-nature connections in children and adolescents: Insights from a meta-analysis. *Environmental Education Research, 31*(2), 245–261. https://doi.org/10.1080/13504622.2024.2404206

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