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Growing with Green: How Parents Nurture Children's Biophilic Preferences for a Sustainable Future

Huizi Deng [1,2,*], Muhammad Azzam Ismail [3,*], Dan He [4], Yunlong Niu [4,5] and Raha Sulaiman [6]

1 Art Design College (Public Art Education Center), Henan University of Urban Construction, Pingdingshan 467036, China
2 Department of Architecture, Faculty of Built Environment, Universiti Malaya, Kuala Lumpur 50603, Malaysia
3 Healthy and Sustainable Built Environment Research Center, College of Architecture, Art and Design, Ajman University, Ajman P.O. Box 346, United Arab Emirates
4 Department of Urban and Regional Planning, Faculty of Built Environment, Universiti Malaya, Kuala Lumpur 50603, Malaysia; hildadan111@gmail.com (D.H.); niuyunlong95@gmail.com (Y.N.)
5 School of Fine Arts, Huaibei Normal University, Huaibei 235000, China
6 Department of Building Surveying, Faculty of Built Environment, Universiti Malaya, Kuala Lumpur 50603, Malaysia; rahasulaiman@um.edu.my
* Correspondence: huizideng726@gmail.com (H.D.); muhammad.ismail@ajman.ac.ae (M.A.I.)

Abstract

Children's affinity for natural elements, or biophilic preferences, has gained increasing recognition as a cornerstone of family-centered sustainability. This study examines how parental factors, specifically environmental attitudes and in-home biophilic design plus guidance, directly shape children's preference for nature-infused environments. A cross-sectional survey (N = 397) for parents collected data on household greenery, animal care, parental attitudes toward environmental responsibility, and the degree of child involvement with natural elements. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), the analysis identified proactive parental mindsets and frequent biophilic home modifications as significant predictors of stronger child affinity for plants, water features, and other nature-inspired components. The findings highlight several key parental and environmental factors that contribute to the development of children's biophilic preferences, underscoring the importance of coordinated efforts among families, communities, and policymakers to nurture children's environmental consciousness. By highlighting how indoor greenery, small-scale animal care, and intentional parental support can foster early engagement with nature, this research offers fresh insights into the synergy between biophilic design and sustainable family practices. Emphasizing the potential role of home-based natural elements in enhancing children's environmental awareness, the study concludes that nature-rich living spaces and holistic sustainability interventions are essential for empowering the next generation to shape a more sustainable future.

Keywords: parental environmental attitude; biophilic design; children's preference; nature affinity; family sustainability

Academic Editor: Gwynne Á. Mhuireach

Received: 18 February 2026
Revised: 19 March 2026
Accepted: 7 April 2026
Published: 14 April 2026

1. Introduction

In recent decades, the rapid pace of urbanization has substantially reduced children's day-to-day engagement with natural elements, a phenomenon often associated with diminished environmental sensitivity and weaker pro-environmental tendencies [1,2]. The biophilia hypothesis posits that humans possess an inherent inclination to connect with nature and living organisms [3,4]. This innate affinity, commonly referred to as "biophilic preferences," is especially salient among children, who stand to benefit profoundly cognitively, socially, and emotionally from consistent exposure to natural environments [5,6].

While considerable literature underscores the role of schools and public spaces in cultivating children's environmental awareness, the significance of the family particularly parents, as a cornerstone for shaping young children's environmental attitudes and actions has garnered increasing attention [7,8]. Parents influence children's values and behaviors through direct instruction, modeling, and environmental scaffolding [9,10]. One emerging avenue of such scaffolding is home-based biophilic design that incorporates natural light, indoor plants, and small-scale gardens, and nurtures animals within domestic settings [11,12]. Despite its promise, our understanding of how parents' own environmental attitudes and self-efficacy translate into structured biophilic home environments that foster children's pro-nature preferences remains partial [13].

1.1. Problem Statement and Research Gaps

Although prior studies have explored parental socialization processes and children's ecological attitudes [7,14], several gaps persist. First, few investigations detail the specific mechanisms through which parental environmental attitudes (PEA) and parental environmental self-efficacy (PESE) foster or inhibit children's biophilic preferences (CBP). Clarifying these mechanisms is critical, given that positive parental mindsets alone may not suffice to induce observable behavioral changes in children [10]. Second, the efficacy of biophilic home elements, such as integrating greenery, water features, or nature-inspired décor, in children's engagement with nature is understudied [12]. Most biophilic research to date emphasizes public buildings, workplaces, or educational settings [11,12,15,16], leaving household-scale interventions comparatively unexplored. Third, few studies systematically incorporate parent–child nature communication (PCNC) as an essential vector for shaping children's environmental preferences, despite evidence that active parental guidance can bridge children's abstract knowledge and real-life ecological behaviors [17].

1.2. Research Objectives and Hypotheses

Against this backdrop, this study aims to examine the relationships among parental environmental attitudes, parental environmental self-efficacy, and biophilic home environments and their effects on children's biophilic preferences. Guided by pro-environmental socialization [7] and biophilic design theories [5,11,15,16], the study specifies the following objectives:

1. Investigate how parental environmental attitudes (PEA) influence children's biophilic preferences (CBP).
2. Examine the influence of parental environmental self-efficacy (PESE) on children's biophilic preferences (CBP).
3. Assess the role of biophilic home environments (BHE) in promoting children's affinity for nature.
4. Evaluate the moderating role of parent–child nature communication (PCNC) in the relationship between biophilic home environments (BHE) and children's biophilic preferences.

The hypotheses proposed are:

H1. *Parental environmental attitudes positively influence children's biophilic preferences.*

H2. *Parental environmental self-efficacy mediates the relationship between parental attitudes and children's biophilic preferences.*

H3. *Biophilic home environments positively affect children's biophilic preferences.*

https://doi.org/10.3390/architecture6020063

H4. *Parent–child nature communication positively moderates the relationship between biophilic home environments and children's biophilic preferences.*

1.3. Significance of Study

From a theoretical standpoint, this research advances our understanding of biophilic preferences in children by merging insights from environmental psychology, family socialization, and design management. By highlighting how parental attitudes, self-efficacy, and intentional home-based interventions converge to nurture children's pro-environmental orientations, the study addresses calls to broaden biophilia research to everyday living contexts [11,12]. Empirically, the findings will guide families, educators, and policymakers in crafting practical interventions, ranging from minor changes in household décor to more structured parental-child nature activities to instill deeper ecological consciousness and sustainable behaviors from early childhood onward [17]. Furthermore, by applying a Partial Least Squares Structural Equation Modeling (PLS-SEM) approach [18], the study offers robust, nuanced insights into the interrelationships among parental cognition, design environment, and childhood nature affinity. Ultimately, the synergy between biophilic design and supportive family practices may serve as a critical lever for empowering the next generation toward shaping a more sustainable future.

2. Literature Review

2.1. Concept of Biophilic Preferences and Child Development

Edward O. Wilson's Biophilia hypothesis [3] posits an innate tendency for humans to seek connections with nature and other forms of life. Subsequent research has identified early childhood as a formative period where these inherent biophilic inclinations can be nurtured [19,20]. Children who engage regularly with natural elements such as plants, water features, or animals exhibit stronger cognitive development, reduced stress, and improved emotional resilience [1,2]. Proponents argue that even simple, everyday engagements (e.g., caring for small plants or observing insects) can cultivate curiosity, enhance sensory perception, and foster ecological awareness [6].

Critically, recent empirical studies underscore the link between children's early biophilic exposure and later pro-environmental behaviors [8,21]. This link is often conceptualized as "child's biophilic preference" (CBP), reflecting the child's affinity or attraction to natural elements. In many measurement approaches, CBP is assessed through items gauging children's eagerness to spend time in nature, fascination with living organisms, and enjoyment of green spaces [9]. A robust CBP has been associated with long-term conservation attitudes and sustainable lifestyle choices [22].

2.2. Parental Environmental Attitude (PEA) and Child Ecological Socialization

Parental environmental attitude (PEA) represents parents' cognitive and affective orientations toward environmental stewardship [7,23]. These attitudes, which can range from strong pro-conservation beliefs to more ambivalent or even skeptical views, significantly shape how families engage with nature and interpret ecological information. According to social learning theory [24], children model behaviors and attitudes observed in significant adults, particularly parents. Consequently, parents with robust pro-environmental attitudes often create a family culture that values sustainability, encourages resource conservation, and normalizes eco-friendly decisions [25,26].

Bronfenbrenner's ecological systems theory [27] highlights the immediate familial setting (microsystem) as crucial for a child's development. Within this context, parental environmental attitudes permeate daily routines like recycling, composting, and reducing energy use, ultimately influencing children's perceptions of what is "normal" or expected in environmentally responsible households [10]. For instance, if parents consistently articulate positive views about nature, highlight biodiversity, or stress the importance of waste reduction, children may internalize these perspectives and develop stronger ecological sensibilities [8].

2.3. Parental Environmental Self-Efficacy (PESE)

While attitudes set a conceptual foundation, parental environmental self-efficacy (PESE) addresses the confidence parents have in effectively implementing pro-environmental behaviors and influencing their children's ecological mindset [24,28,29]. High PESE is reflected in parents who believe they can consistently engage children in activities like urban gardening or litter cleanups. In contrast, low self-efficacy may manifest as doubts about whether children are "too young" or whether certain environmental actions "won't make a difference."

Research indicates that parents with high PESE are more likely to seek out knowledge, resources, and supportive communities to reinforce eco-friendly family norms [28,30]. They also tend to allocate time for nature exploration, be it weekend hikes, visiting eco-centers, or simply discussing environmental issues at home [31,32]. These behaviors, in turn, model persistence and competence, fostering children's parallel sense of self-efficacy [10]. In measurement terms, items addressing PESE in a questionnaire might gauge how capable parents feel about guiding children to appreciate wildlife, reduce household waste, or make greener consumer choices [33].

2.4. Biophilic Home Environment (BHE)

Biophilic design principles emphasize incorporating nature into built environments to improve well-being [5,11,15,34]. Although often discussed in large-scale projects (e.g., offices, public buildings), these principles are equally relevant in domestic contexts [35]. Biophilic Home Environment (BHE) refers to the integration of natural elements and nature-related features within residential indoor spaces that allow children to experience a relationship with nature in their daily home setting. Typical examples include indoor plants, natural lighting, water features such as fish tanks, the use of natural materials (e.g., wood or stone), and areas dedicated to observing or interacting with small animals [12,34]. Such elements aim to evoke tranquility, stimulate children's senses, and nurture consistent contact with nature [13].

Evidence suggests that children living in greener homes exhibit stronger preference for natural elements, enhanced mental health, and improved attention spans [17,36]. Moreover, BHE can complement the educational and attitudinal influences discussed earlier: if parents demonstrate PEA and have high PESE, the presence of greenery, animals, or natural textures in the home can reinforce daily eco-learning [29,37].

2.5. Parent–Child Nature Communication (PCNC)

Communication processes within the family significantly shape children's environmental cognition and behavior [38,39]. Parent–child nature communication (PCNC) involves discussing ecological issues, sharing experiences from outdoor activities, or narrating stories about wildlife and conservation. Unlike passive observation of parental behaviors, PCNC creates an active learning space where children ask questions, receive explanations, and develop critical thinking about environmental themes [40].

Studies emphasize that quality nature communication fosters emotional bonds to flora and fauna, reinforcing children's sense of responsibility for living things [2,7,41]. For instance, a simple conversation about why the family recycles or how birds build nests can spark children's curiosity and empathy toward nature [42]. PCNC also encourages reflective thought when children connect an experience (e.g., a visit to a nature reserve) with broader environmental insights [43]. In your survey, PCNC-related items might ask how frequently parents talk to children about ecosystems, describe environmental changes, or engage in dialogue after a family hike.

2.6. Child's Biophilic Preference (CBP) and Sustainable Behaviors

Child's biophilic preference (CBP) integrates the degree of fascination, emotional affinity, and active seeking of natural elements [9,19]. Empirical work consistently links CBP to environmentally responsible actions in later adolescence and adulthood [8,21]. When children frequently express enjoyment in nature-based tasks or show deep curiosity about plants and animals, they are more likely to volunteer in conservation programs or adopt sustainable consumption patterns in the future [6].

Researchers utilize validated scales or observational checklists to measure CBP, capturing dimensions like "nature enjoyment," "nature comfort," and "willingness to learn about nature" [9]. These metrics often appear in environmental psychology to predict outcomes such as recycling habits, water conservation, and biodiversity support [44].

2.7. Proposed Conceptual Framework

Drawing from the preceding literature, Figure 1 presents an integrated framework where Parental Environmental Attitude (PEA) and Parental Environmental Self-Efficacy (PESE) are critical antecedents shaping the household's eco-culture [29,39,45,46]. Biophilic Home Environment (BHE) anchors daily access to natural elements, while Parent–Child Nature Communication (PCNC) promotes active conversation around ecological topics [7,12,17,26]. These factors collectively influence Child's Biophilic Preference (CBP), a pivotal construct in predicting future sustainable behaviors [2,6].

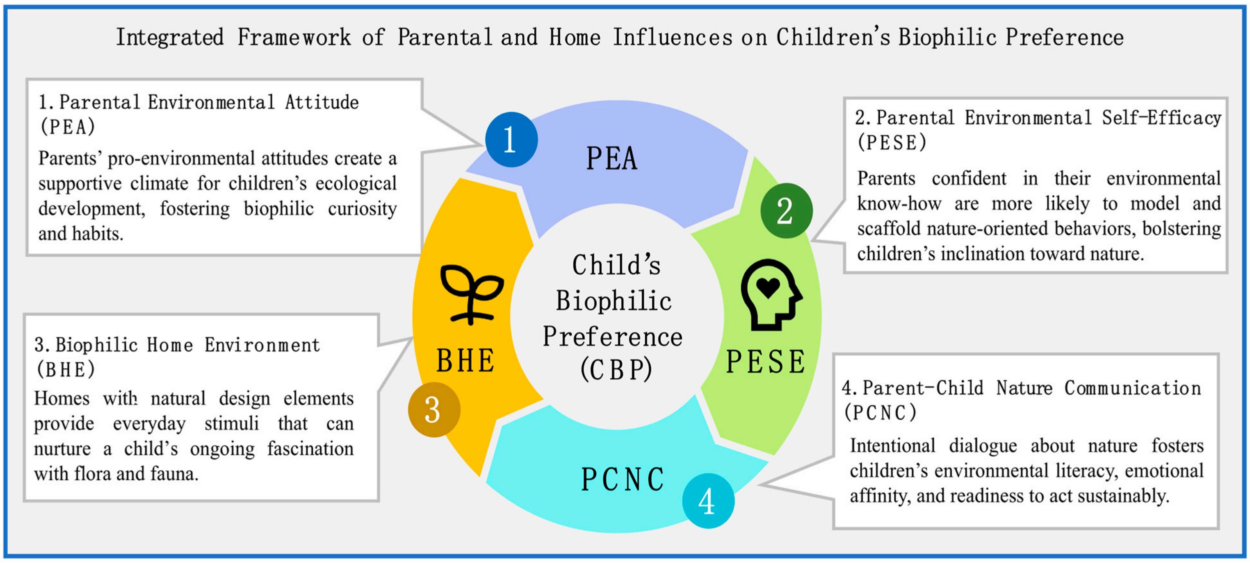

Figure 1. Integrated Framework of Parental and Home Influences on CBP.

3. Materials and Methods

A cross-sectional survey design underpins this research, a commonly employed quantitative approach that captures data from participants at a single point in time [47]. This design is particularly appropriate for understanding relationships among psychological (PEA, PESE), environmental (BHE), and communication-oriented variables (PCNC), as they converge to shape children's natural inclinations [2].

3.1. Rationale

Cross-sectional methods were chosen for both practical and theoretical reasons. First, they allow for the efficient collection of a reasonably large sample, crucial when exploring multivariate associations among family-based constructs [7]. Second, the relatively stable nature of parental attitudes and household conditions over short periods means that a single snapshot can provide valid insights into underlying correlational structures [18].

3.2. Participants and Sampling

3.2.1. Target Population

The target population consisted of parents or primary caregivers with children between three and twelve years old, capturing preschool to early elementary years, a phase where children's emotional and cognitive ties to nature can be strongly shaped by family influences [8,20]. Participants were recruited from urban areas in mainland China, and the questionnaire was administered in Chinese to ensure linguistic accessibility for respondents.

3.2.2. Sampling Strategy

A nonprobability sampling approach, blending convenience and purposive elements, was employed to ensure broad coverage of family demographics [48]. Recruitment channels included:

- Schools and Kindergartens: Collaborations with administrators and teachers to disseminate survey links or paper questionnaires.
- Community Centers: Distribution of surveys at family-oriented events or environmental workshops.
- Online Platforms: Posting invitations in parenting forums and social media groups to reach a geographically diverse audience.

These mechanisms aimed to gather varied socioeconomic and educational backgrounds, mitigating potential selection bias [49].

3.2.3. Sample Size Determination

Using the formula $n = \frac{Z^2 \times p \times (1-p)}{E^2}$ with Z = 1.96 (95% confidence), p = 0.5, and E = 0.05, the minimum required sample size was approximately 384 [50,51]. To account for incomplete or invalid responses, the study targeted over 400. Ultimately, 436 questionnaires were collected from which 397 valid responses were retained after data cleaning.

In addition, the adequacy of the sample size was evaluated according to common PLS-SEM guidelines. Following the widely used 10-times rule, the minimum sample size should be at least ten times the maximum number of structural paths directed at a latent construct in the model [18]. In the present study, the dependent construct Children's Biophilic Preference (CBP) receives four structural paths (from BHE, PEA, PCNC, and PESE), indicating a minimum requirement of 40 observations.

Furthermore, recent methodological recommendations suggest that PLS-SEM studies should ideally include at least 200 observations for complex models to ensure statistical power and stability of estimates [18]. With 397 valid responses, the sample size in this study substantially exceeds these recommended thresholds.

3.2.4. Participant Characteristics

Preliminary analyses revealed a balanced distribution of parental demographics:

- Gender: Approximately 58% mothers, 42% fathers.
- Age Range: Predominantly 25–45 years old (around 83%), with the remainder younger than 25 or older than 45.

- Education Level: About 11% had a high school diploma or below, 57% held a bachelor's degree, and 32% possessed graduate or higher qualifications.
- Children's Age: Nearly 49% of the children were aged 3–6, and 51% fell within 7–12 years old.

3.2.5. Representativeness

While a nonprobability approach cannot guarantee population-level representativeness, steps were taken to minimize bias. For instance, surveys were distributed beyond environmental interest groups to reduce self-selection bias [52]. Sample demographics were evaluated to confirm variability across socioeconomic strata.

3.3. Instrument Development and Measures

3.3.1. Questionnaire Structure

The questionnaire was structured into six primary sections, each introduced by a brief overview of the study's purpose and instructions. The first section addressed demographic information, including participant age, gender, educational background, and the child's age. Following this, Section B focused on Parental Environmental Attitude (PEA), guided by Dunlap's the New Ecological Paradigm (NEP) framework [53], which gauges parents' overarching environmental stance. Section C evaluated Parental Environmental Self-Efficacy (PESE), building on Bandura's self-efficacy framework [54] to measure parents' confidence in guiding their child's environmental awareness and nature-related activities. Section D examined the Biophilic Home Environment (BHE), referencing Kellert and Calabrese [5], which reflects the integration of natural elements within the home setting, such as indoor plants, natural materials, water features, or small animals [12]. Section E assessed Parent–Child Nature Communication (PCNC), inspired by Cheng & Monroe [40] and Grønhøj and Thøgersen [7], focusing on the frequency and depth of nature-related discussions or shared experiences between parents and children. Finally, Section F captured the Child's Biophilic Preference (CBP), drawing on Larson et al. [9] and Otto and Pensini [8] to measure children's interest in and enjoyment of natural elements. The final measurement model included five latent constructs: BHE (5 items), PEA (5 items), PESE (4 items), PCNC (4 items) and CBP (5 items). All items were measured using a 10-point Likert scale, ranging from 1 ("Strongly Disagree") to 10 ("Strongly Agree"). The full questionnaire items and measurement properties are provided in Supplementary Materials.

3.3.2. Pilot Testing and Revision

To ensure clarity and cultural appropriateness, a pilot test involved 30 parents from differing education and income brackets. Minor wording adjustments ensued to improve comprehension. Cronbach's alpha (α) was calculated for each subscale in the pilot, with $\alpha \geq 0.70$ indicating acceptable internal consistency [18].

3.3.3. Translation Procedure

The questionnaire was originally developed in Chinese, as the target respondents were Chinese-speaking parents. To ensure linguistic equivalence, the survey instrument was translated into English and then back-translated into Chinese by two independent bilingual researchers. Any discrepancies between the two versions were discussed and resolved to ensure conceptual consistency.

3.4. Data Collection Procedure

3.4.1. Administration Process

Recruitment was undertaken via multiple avenues described in Section 3.2. Parents received an invitation message explaining the study's objective and assurances of confidentiality [47]. For physical copies, teachers or community organizers facilitated the distribution and collection, while online forms were shared via secure survey links.

3.4.2. Ethical Considerations

Participants were informed of their right to voluntary participation and withdrawal without repercussion. Informed consent was implicit once they proceeded to fill out the survey. No personally identifying details were collected, and all data were stored on password-protected devices. Where required, a Universiti Malaya Research Ethics Committee (UMREC) approval was obtained prior to data gathering.

3.5. Data Analysis Methods

All constructs in this study were modeled as reflective measurement models. Although indicators of the Biophilic Home Environment (BHE) represent different types of natural elements (e.g., plants, natural materials, animals, daylight), these indicators were conceptualized as manifestations of an underlying latent orientation toward incorporating biophilic features within the home. Households with stronger biophilic orientation are expected to consistently exhibit multiple types of nature-related elements.

This reflective specification aligns with prior research in environmental psychology and sustainability studies where environmental attributes are treated as reflective indicators of broader environmental characteristics.

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) via software such as SmartPLS (v.4), known for its robust handling of complex models and fewer distributional constraints [18]. The reflective measurement models need to estimate the relationships between the reflective latent variables and their indicators (i.e., outer loadings). Evaluation of reflective measurement models includes cut-off criteria, as explained in Table 1.

Table 1. Benchmarks of validity, reliability and collinearity.

Index	Benchmark
Construct validity	
a. Convergent validity	
1. Loading	≥0.70 and significant ($p < 0.05$)
2. AVE	≥0.50
b. Discriminant validity	
1. Fornell-Larcker criterion	Achieved when the square root of AVE of a latent variable is larger than its correlations with other latent variables in the PLS- SEM model.
2. Cross-loadings	Achieved when the loading value of an indicator to its latent variable is larger than its cross-loading values to other latent variables in the PLS-SEM model.
3. Heterotrait–monotrait ratio (HTMT)	≤0.90
Reliability	
1. Cronbach's alpha reliability	≥0.70
2. Composite reliability(rho_a)	≥0.70
3. Composite reliability(rho_c)	≥0.70
Collinearity analysis	
Collinearity statistics (VIF)	≤5.0

After validating the measurement model for construct validity, reliability, discriminant validity, and collinearity, the structural model analysis focuses on path coefficients, R^2

values, effect sizes (f^2), and predictive relevance (Q^2). These assessments clarify the model's explanatory and predictive capabilities, revealing how the constructs relate. Table 2 summarizes key criteria for evaluating the structural model [55]. The final interpretation linked quantitative outcomes back to the theoretical framework. The results were contextualized within existing literature on environmental socialization, home-based biophilic design, and child development, forming the foundation for discussion in subsequent sections.

Table 2. Assessment of the structural model.

Validity Type	Criterion	Description
Model validity	Coefficient of determination (R^2)	Attempts to measure the explained variance of an LV relative to its total variance. Values of approximately 0.670 are considered substantial, values around 0.333 moderate, and values around 0.190 weak.
	Path coefficients	Path coefficients between the LVs should be analyzed in terms of their algebraic sign, magnitude, and significance.
	Effect size (f^2)	Measures if an independent LV has a substantial impact on a dependent LV. Values of 0.020, 0.150, 0.350 indicate the predictor variable's low, medium, or large effect in the structural model.
	Predictive relevance (Q^2)	The Q^2 statistic is a measure of the predictive relevance of a block of manifest variables. A tested model has more predictive relevance the higher Q^2 is, and modifications to a model may be evaluated by comparing the Q^2 values. The proposed threshold value is $Q^2 > 0$. The predictive relevance's relative impact can be assessed by means of the measure q^2.

In summary, this methodology section outlines the rigorous approach taken to collect and analyze cross-sectional data from parents of children aged 3–12. By combining a well-grounded sampling strategy, carefully validated measurement scales, ethical data collection procedures, and sophisticated PLS-SEM analysis, the study aims to elucidate the roles played by parental attitudes, self-efficacy, home design, and communication in shaping children's biophilic preferences.

4. Results

This section presents the detailed findings of the study based on Partial Least Squares Structural Equation Modeling (PLS-SEM). Following common practice [18], the results are divided into the measurement model assessment (validity and reliability of constructs) and the structural model evaluation (hypothesis testing and predictive power).

4.1. Measurement Model Assessment

4.1.1. Reliability and Convergent Validity

All constructs (BHE, CBP, PCNC, PEA, and PESE) demonstrate high internal consistency, with Cronbach's alpha values ranging from 0.868 to 0.909, well above the recommended threshold of 0.70 [56]. Composite Reliability (rho_c) also lies between 0.868 and 0.909, indicating robust reliability for each latent construct [18].

Convergent validity was evaluated through Average Variance Extracted (AVE). Values for all five constructs exceed 0.60 (ranging from 0.622 to 0.668), surpassing the minimum criterion of 0.50 [57]. Additionally, the high outer loadings (mostly above 0.75) suggest that each item strongly measures its intended latent variable. These results confirm adequate internal consistency and convergent validity of the measurement model.

4.1.2. Discriminant Validity

Discriminant validity was assessed via both the Fornell-Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio [58]. Fornell-Larcker, each construct's square root of AVE (on the diagonal) is greater than its correlations with other constructs. Moreover, regarding HTMT, all ratios are below the conservative 0.85 cutoff, confirming that no pair of constructs exhibits problematic overlap. Overall, these indicators support that each latent variable is empirically distinct from the others, fulfilling fundamental criteria for discriminant validity [18].

4.2. Structural Model Evaluation

4.2.1. Model Fit and Predictive Relevance

The model's goodness-of-fit was assessed using multiple established criteria. As shown in Table 3, the Standardized Root Mean Square Residual (SRMR) values of 0.026 for both saturated and estimated models were significantly below the recommended threshold of 0.08 [58], indicating excellent model fit. The Normed Fit Index (NFI) of 0.941 similarly supported strong model-data alignment. The chi-square statistic (395.151) along with discrepancy measures (d_ULS = 0.192; d_G = 0.205) suggested minimal model misspecification. These results collectively demonstrate robust support for both the measurement and structural components of the proposed model.

Table 3. Model Fit Indices.

	Saturated Model	**Estimated Model**
SRMR	0.026	0.026
d_ULS	0.192	0.192
d_G	0.205	0.205
Chi-square	395.151	395.151
NFI	0.941	0.941

The model demonstrated strong predictive capability, as evidenced by the cross-validated predictive relevance measures presented in Table 4. The Q^2 predict value of 0.802 for CBP indicates that the exogenous constructs (BHE, PCNC, PEA, and PESE) explain 80.2% of the variance in CBP, demonstrating excellent predictive power. Supporting metrics including RMSE (0.448) and MAE (0.348) further confirm the model's predictive accuracy.

Table 4. Predictive Performance Metrics.

	Q^2 Predict	**RMSE**	**MAE**
CBP	0.802	0.448	0.348

4.2.2. Coefficient of Determination (R^2)

The R^2 for CBP stands at 0.936 (adjusted R^2 = 0.935) (Table 5), indicating that 93.6% of the variance in Child's Biophilic Preference can be explained by Biophilic Home Environment (BHE), Parent–Child Nature Communication (PCNC), Parental Environmental Attitude (PEA), and Parental Environmental Self-Efficacy (PESE). Such a high R^2 highlights the strong explanatory power of the proposed model [59].

Table 5. Variance Explained in Child's Biophilic Preference (CBP).

	R-Square	**R-Square Adjusted**
CBP	0.936	0.935

4.2.3. Effect Sizes (f^2)

The relative contribution of each predictor was assessed using Cohen's f^2 effect sizes (Table 6). BHE showed the strongest effect ($f^2 = 1.108$), followed by PEA ($f^2 = 0.618$), PCNC ($f^2 = 0.433$), and PESE ($f^2 = 0.331$). Following Cohen [59] benchmarks, BHE and PEA demonstrate large effects, while PCNC and PESE show moderate-to-large effects on CBP.

Table 6. Effect Sizes of Predictors on Child's Biophilic Preference.

Predictor	f^2	Effect Magnitude
BHE	1.108	Large
PCNC	0.433	Large
PEA	0.618	Moderate–Large
PESE	0.331	Moderate

4.2.4. Path Coefficients and Significance

Bootstrapping analysis with 5000 resamples confirmed the statistical significance of all hypothesized paths, with all *t*-statistics exceeding 1.96 ($p < 0.001$). As shown in Figure 2, both reflective indicators and structural paths demonstrated significant relationships at the $p < 0.001$ level. The structural model revealed:

- BHE → CBP: Original sample coefficient = (not directly listed above, but implied by $f^2 = 1.108$ and the negative cross-loading matrix).
- PEA → CBP: Large positive path, t-statistic above threshold.
- PCNC → CBP: Moderately strong path coefficient ($f^2 = 0.433$).
- PESE → CBP: Also statistically significant, *t*-statistics > 1.96, indicating parents' self-efficacy positively influences children's nature-oriented preferences.

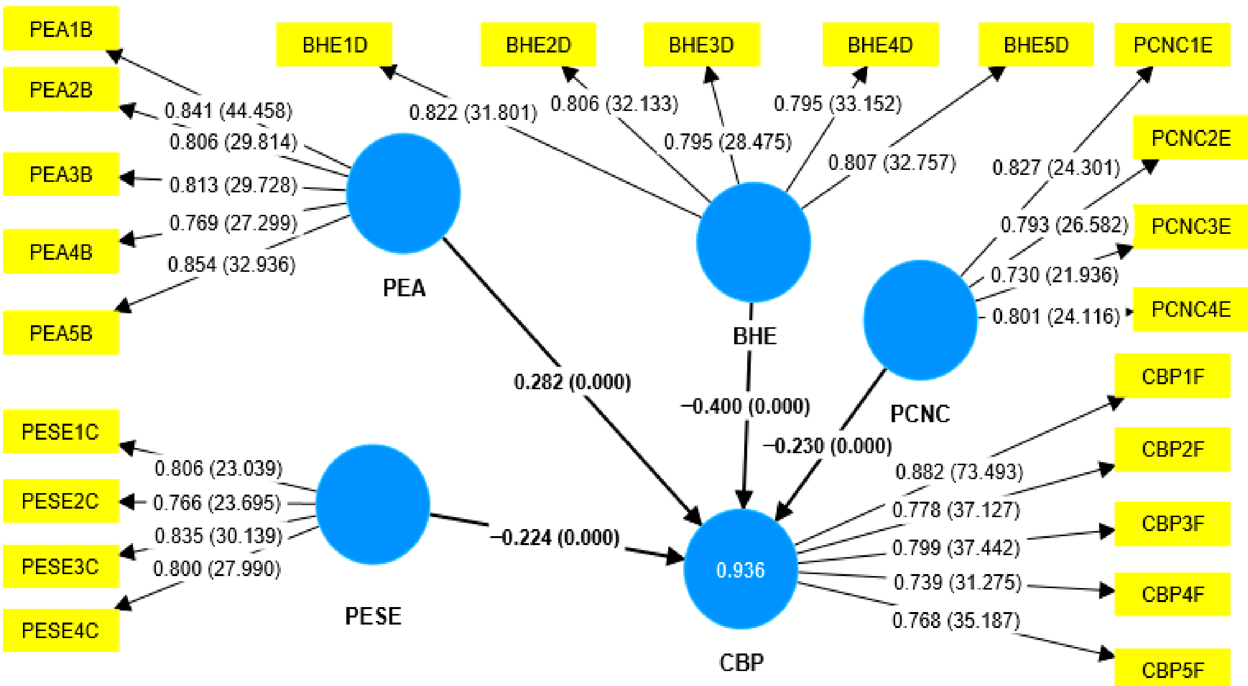

Figure 2. Structural Model with Standardized Path Coefficients.

The results provide robust empirical support for the hypothesized relationships, demonstrating significant positive effects of biophilic home environment (BHE), parent–child nature communication (PCNC), parental environmental attitude (PEA), and parental environmental self-efficacy (PESE) on children's biophilic preferences (CBP) [9].

4.3. Summary of Key Findings

The empirical results substantiate the proposed theoretical model, demonstrating both robust measurement properties and strong predictive power for children's biophilic preferences (CBP). All latent constructs (BHE, CBP, PCNC, PEA, PESE) exhibited excellent reliability (Cronbach's alpha and composite reliability) and validity (convergent and discriminant). The structural model revealed particularly strong effects of biophilic home environment (BHE; f^2 = 1.108) and parental environmental attitude (PEA), consistent with existing literature on environmental influences in child development [5,7,15]. Parent–child nature communication (PCNC) and parental environmental self-efficacy (PESE) showed moderate-to-strong effects, aligning with established theories of social learning [54] and environmental education [40]. The model demonstrated exceptional fit (SRMR = 0.026, NFI = 0.941) and explanatory power (R^2 = 0.936), collectively supporting the integrated framework of environmental and social factors shaping children's nature orientation. By the data results of these findings, the study offers a compelling evidence base supporting the roles of both environmental design (BHE) and parental factors (PCNC, PEA, PESE) in enhancing children's biophilic preferences.

5. Discussion

5.1. Interpretation of Findings

The current study's findings reveal that Biophilic Home Environment (BHE) and Parental Environmental Attitude (PEA) exert the greatest influence on Child's Biophilic Preference (CBP), while Parent–Child Nature Communication (PCNC) and Parental Environmental Self-Efficacy (PESE) also demonstrate statistically significant though somewhat smaller effects. These results underscore the critical role of an enriched home environment, replete with natural elements, plants, and opportunities for children to interact with flora and fauna [5,15,19] in fostering children's inclination toward nature. In parallel, parents with positive environmental attitudes provide an overarching framework that reinforces a value system conducive to ecological stewardship, in line with prior research on environmental socialization [7]. In this study, children's biophilic preference (CBP) is used as a key indicator reflecting children's inclination toward nature-related experiences, which has been widely linked in previous research to the development of pro-environmental awareness and future environmental responsibility [60]

Comparing these outcomes with previous studies, the high explanatory power (R^2 = 0.936) aligns with results from environmental psychology and family studies, which suggest that everyday exposure to nature and direct parental modeling substantially shape children's pro-environmental orientations [8,9]. By highlighting a combined effect of physical environmental factors (BHE) and attitudinal/psychological factors (PEA, PESE, PCNC), the study bridges theoretical gaps between ecological design literature [12] and child development frameworks [54]. Notably, the strong effect size of BHE offers new insights: although parental communication and self-efficacy are important, tangible manifestations of nature within the household may be even more vital for consistently engaging children's senses and curiosity about the natural world [61].

From a theoretical perspective, these findings contribute to the literature in at least two ways. First, they empirically validate that integrating natural elements at home (e.g., living walls, indoor plants, small aquariums) can serve as a potent catalyst for children's biophilic preferences [5,11,15]. Second, the interplay between parental attitudes and environmental self-efficacy sheds light on how social learning processes [32,54] interact with physical design to mold young minds. This underscores a more comprehensive ecological systems approach [27], where the micro-level family environment and the macro-level context (community norms, cultural values) jointly guide environmental socialization.

5.2. Practical Implications

5.2.1. Family-Level Recommendations

The study underscores the importance of incorporating nature into the home. Parents can utilize simple strategies such as placing indoor plants, maintaining small pets, or designating a "nature corner" with natural materials (wood, stones, or shells) to stimulate children's engagement [12].

From a spatial design perspective, even small living areas can incorporate biophilic elements through compact and accessible design interventions. For example, placing two to five small potted plants in frequently used spaces such as living rooms, balconies, or children's study areas can increase children's daily visual contact with greenery.

In urban apartments where outdoor access may be limited, families may designate a "micro nature zone" (e.g., a small shelf, windowsill, or corner table) that contains plants, natural textures, and seasonal nature objects such as leaves, shells, or seeds. These small-scale design interventions can help maintain consistent exposure to natural elements within the household environment. Parental discussions that complement these physical enhancements—such as explaining how plants grow or why recycling benefits the planet—can further reinforce children's positive attitudes toward nature [40].

5.2.2. Community and Policy Initiatives

Given the effectiveness of BHE, local governments or community organizations might collaborate with families by offering workshops or subsidies for greening home spaces. Community-level "green toolkits" can include free seedlings, instructions on low-cost composting, or resources for indoor gardening [62]. Policymakers could also consider zoning regulations that encourage biophilic design features in residential areas, ensuring that even within high-density housing environments, children have ongoing contact with nature [63].

5.2.3. Educational and School Collaborations

Schools can integrate family-based environmental projects such as take-home nature journals or parent–child planting assignments to amplify children's home experiences. By complementing in-school "green" curricula with at-home engagements, teachers and parents jointly foster consistent ecological understanding. For instance, classroom discussions about local biodiversity could be extended by parent-led "mini field trips" in backyards or community gardens, thereby strengthening the synergy between the school setting and the household environment [7].

5.3. Limitations

5.3.1. Sample Representativeness

Although attempts were made to gather a diverse parental population, the reliance on convenience and purposive sampling may limit generalizability. Cultural and regional factors (e.g., urban vs. rural contexts) might influence the extent to which families can implement biophilic home environment [52]. Future studies that employ stratified random sampling or target different geographic locations could address this shortfall.

5.3.2. Study Design

The cross-sectional nature of the research captures parent–child interactions at a single time point, hindering strong causal inferences [47]. While statistical methods like PLS-SEM can suggest directionality, experimental or longitudinal designs are warranted to truly verify temporal changes in children's preferences. Additionally, self-reported questionnaires risk social desirability bias if parents overstate pro-environmental behaviors or home-based natural design elements [49].

5.3.3. Measurement Instruments

Some scale items were adapted from existing literature [5,11,12,53], whereas others were newly created to match local contexts. Although pilot testing supported scale reliability, further validation (e.g., confirmatory factor analyses in multiple independent samples) can strengthen the external validity of the measures [18].

5.4. Future Research Directions

5.4.1. Longitudinal or Experimental Studies

Future research might track the same families over multiple years to observe whether children's biophilic preferences evolve alongside changes in home design or parental attitudes. Alternatively, intervention-based experiments where families are guided to implement specific biophilic upgrades could ascertain causal effects [54].

5.4.2. Cross-Cultural Comparisons

The cultural dimensions influencing parental norms and attitudes toward nature remain underexplored. Comparative studies across different societies (e.g., Eastern vs. Western contexts) could reveal whether the observed relationships among BHE, PEA, PCNC, and PESE hold universally or vary by cultural setting [64].

5.4.3. Expanding Variables

Future models may incorporate broader factors such as parental-child personality traits, socioeconomic status, or community-level green infrastructure to deepen our understanding of how multiple layers of influence converge to shape children's environment-related cognition and behavior [27]. Spatial analyses of actual home layouts or real-time observation of parent–child interactions around nature could offer more nuanced insights.

6. Conclusions

6.1. Overall Summary

In summary, this study elucidates how four key constructs, which are Biophilic Home Environment (BHE), Parental Environmental Attitude (PEA), Parent–Child Nature Communication (PCNC), and Parental Environmental Self-Efficacy (PESE), collectively nurture children's biophilic preferences. Statistical evidence (R^2 = 0.936) underscores their strong cumulative impact, with BHE and PEA emerging as the most powerful predictors. These findings underscore the integrative nature of environmental design, parental influence, and communicative processes in shaping children's ecological inclination, supporting prior claims in environmental psychology and child development.

6.2. Contributions to a Sustainable Future

By spotlighting the potency of a nature-rich home environment, the study makes a tangible contribution to sustainable family practices. Encouraging biophilic design principles at the household level not only fosters children's immediate affinity toward nature but may contribute to the development of long-term environmental awareness and positive attitudes toward nature. From a policy standpoint, the research advocates for cross-sector collaboration among educators, community planners, and policymakers to develop family-friendly, resource-efficient interventions. Such efforts reinforce a comprehensive strategy for environmental stewardship, ensuring that the next generation is both knowledgeable and emotionally invested in ecological well-being.

https://doi.org/10.3390/architecture6020063

6.3. Final Remarks

The role of families in driving sustainable development cannot be overstated. By demonstrating how physical and psychosocial factors within the household intersect to elevate children's engagement with nature, this study calls on academics, educators, and policymakers alike to intensify support for biophilic domestic spaces. The hope is that, through ongoing research and collaborative efforts, we can scale these insights into broader cultural norms, thereby fostering a generation that not only values nature but is also equipped to safeguard it for the future.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/architecture6020063/s1.

Author Contributions: H.D.: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing—original draft, Writing—review and editing, Validation. M.A.I.: Conceptualization, Methodology, Writing—review and editing, Supervision. D.H.: Visualization, Writing—review and editing, Validation. Y.N.: Visualization, Writing—review and editing, Validation. R.S.: Conceptualization, Methodology, Resources, Writing—review and editing, Supervision. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of UNIVERSITI MALAYA (ref no. UM.TNC2/UMREC_2858; 7 September 2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data included in article.

Acknowledgments: The authors would like to express their sincere gratitude to all the research participants who made this study possible.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

SEM	Structural Equation Modeling
PLS-SEM	Partial Least Squares Structural Equation Modeling
PEA	Parental environmental attitudes
PESE	Parental environmental self-efficacy
CBP	Biophilic preferences
BHE	Biophilic home environment
PCNC	Parent–child nature communication
UMREC	Universiti Malaya Research Ethics Committee
AVE	Average Variance Extracted
HTMT	Heterotrait–Monotrait
SRMR	Standardized Root Mean Square Residual
NFI	Normed Fit Index

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