BIOPHILIC DESIGN IN CHILDREN'S PLAYGROUNDS: THE INFLUENCE OF NATURE ON EMOTIONAL HEALTH AND STRESS RELIEF

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ABSTRACT

The focus of the research is to analyze biophilic (nature-integrated) design and its interaction with children's playground activity and emotional well-being based on a comparative behavior mapping protocol applied in three parks in İzmir: Karantina (biophilic), Susuzdede (biophilic), and Göztepe (conventional). We carried out 2-hour observation sessions per site on weekend afternoons over four consecutive weekends (14 Dec – 5 Jan) and marked play locations, movement trajectories, play modes (solo/social/active), and age groups (3–6, 6–9) on schematic base maps to define density and hotspot patterns. Our central finding is that biophilic features, especially water elements and natural materials (wood/rope), abundant trees, and green surfaces—are associated with longer dwell times, richer social/imaginative play, and broader spatial dispersion beyond fixed equipment. These patterns were consistently stronger in Karantina and Susuzdede than in Göztepe, where play remained confined to plastic equipment with shorter stays; a temporary spike on 29 Dec (adjacent bazaar) did not alter this baseline. Methodologically, we contribute a replicable, spatial–behavioral lens that links specific biophilic attributes (e.g., proximity to water, shade, natural textures) to observed engagement patterns via cumulative density mapping over time. This provides an explanation of where and how design elements coincide with play patterns that the literature associates with stress reduction and social cohesion; emotional outcomes were not measured. Although we emphasize strong short-term effects, we acknowledge the constraints of short observation periods and possible observer bias in Data Recordings necessitating future mixed methods and physiological approaches to detect longer term stress- and emotional health impacts.

Keywords: Biophilic Design, Children, Natural Materials, Stress Reduction, Urban Design, Emotional Health.

1. INTRODUCTION

Biophilic design integrates natural elements into built environments to strengthen the human–nature bond and support physical, mental, and emotional well-being. In rapidly urbanizing contexts, children's everyday exposure to nature diminishes, while playing increasingly shifts to equipment-centric, low-variability settings. By deliberately embedding living systems (vegetation), natural materials (wood/stone), water features, daylight, views, and multisensory textures, biophilic design offers a coherent architectural strategy to restore contact with nature and enrich children's play experiences. Applied to playgrounds, this approach can expand affordances beyond standardized apparatus, encouraging exploration, risk negotiation, and cooperative play that traditional designs often under-serve.

Rapid urbanization reduces children's routine contact with nature and compresses outdoor play opportunities, intensifying the need for every day, near-home access to restorative green infrastructure (Louv, 2008; Beatley, 2011). Within this context, biophilic design provides an architectural pathway to reintroduce nature's affordances into play environments.

A large body of research links contact with greenery, water, daylight, and natural textures to reduced physiological stress, improved mood, and attentional restoration. For children specifically, unstructured outdoor play in nature-rich settings supports longer dwell times, more varied movement, imaginative scenarios, and richer peer interaction; water and tactile materials catalyze sensory engagement and collaborative, prosocial behaviors. Early, repeated encounters with nature are also associated with greater environmental awareness later in life. Taken together, this evidence positions biophilic playgrounds as a plausible lever for emotional regulation and developmental gains.

Despite this broad consensus, how specific biophilic attributes translate into spatial–behavioral patterns in real parks remains under-documented. Many studies describe benefits in general terms (e.g., “greener is better”) without locating where within a playground children cluster, linger, or transition; nor do they consistently differentiate effects by age bands or play modes. Moreover, findings are often reported qualitatively, making design transfer difficult for practitioners.

This study addresses that gap by employing a comparative, map-based observational lens to relate biophilic elements—trees and shade, waterside edges and sounds, natural materials and surfaces—to observable shifts in occupancy, dwell time, movement paths, and play modes among two age groups (3–6; 6–9). Focusing on three parks in İzmir—two with prominent biophilic features (Karantina, Susuzdede) and one traditional, equipment-centric site (Göztepe)—we conducted repeated weekend observations across four consecutive weeks. By coding activity nodes and tracing movements on schematic base maps, we derive cumulative density hotspots and dispersion patterns that make the role of design elements spatially explicit and replicable.

Our findings demonstrate consistent contrasts: biophilic settings redistribute activity beyond fixed equipment toward shaded greens and waterside zones, lengthen stays, and elevate social/imaginary play; the traditional site concentrates activity on plastic equipment with shorter engagements, barring transient event-driven anomalies. Beyond documenting these differences, the paper contributes (i) a transferable protocol for behavior-mapping biophilic play, (ii) a compact set of indicators (dwell time, spatial dispersion, social/imaginary play ratios) that practitioners can monitor, and (iii) design-relevant insights about which natural attributes most reliably attract and sustain children’s engagement.

The article first situates biophilic design within environmental psychology and child development, then details the observation protocol and coding scheme. Results are presented with schematic maps and a quantitative summary table, followed by an analytical discussion that links patterns to design decisions and urban policy. We conclude with limitations (e.g., observation windows, context effects) and directions for future mixed-methods and physiological measures to capture longer-term effects on stress and emotional health.

2. THEORETICAL FOUNDATIONS

2.1. Biophilia Theory

Biophilia suggests an evolved human affinity for nature, whereby contact with living systems and natural patterns supports restoration and well-being through stress reduction and recovery from directed attention (Wilson, 1984; Ulrich, 1984; Kaplan, 1995). Biophilic design operationalizes this process architecturally by incorporating vegetation, water, daylight, views, and natural materials to augment multimodal affordances (Kellert, 2008; Kellert & Calabrese, 2015). Among children, exposure to nature is related to longer dwell time, more diverse movement, and more imaginative/cooperative play; it therefore represents a practical lever for socio-emotional development (Kuo & Taylor, 2004; Fjørtoft, 2004). Against this backdrop, our study examines where and how specific biophilic features in real playgrounds (trees/shade, waterside edges and sounds, natural textures) are associated with children’s spatial occupancy beyond fixed equipment and their play modes.

2.2. Environmental Psychology and Children’s Development

Play environments with abundant nature are consistently related to developmental gains in children. People also derive cognitive benefits from greenery in and around schools, with such exposure tied to better attention and more self-regulation, core executive functions upon which learning and classroom behavior are based (Kuo & Taylor, 2004; Taylor & Kuo, 2009). Socio-emotionally, unstructured outdoor play structures cooperative problem-solving, peer negotiation and imaginative role-play, prolonging dwell time, and widening playing context beyond fixed equipment. Naturally uneven surfaces, logs, and climbable structures stimulate gross motor (balance, coordination and agility) whilst also encouraging an amount of calibrated risk-taking which benefits motor planning (Fjørtoft 2004).

Such developmental effects necessarily have motivational and attitudinal implications. Repeated, positive childhood experiences with nature are linked to uplifted mood and restorative play experiences, prompting prosocial behavior and environmental concern that can endure for a lifetime (Barton & Pretty, 2010; Capaldi et al., 2014; Schwass et al., 2021). In play landscapes, biophilic affordances (tree shade, waterside edges and sounds, natural textures) serve as tangible levers by enhancing sensory experiences and movement opportunities as well as social/imaginative play. So framed, the child-development lens illuminates which nature-based features to protect and include when designing or retrofitting play environments.

2.3. Biophilic Design in Built Environments

In applied contexts, biophilic design operationalizes human–nature contact by embedding vegetation (VEG), water (WATER), daylight/views, and natural materials (NATMAT) within everyday settings so as to broaden multisensory affordances (Kellert, 2008; Kellert & Calabrese, 2015). In children's play environments, such attributes are associated with longer engagement and more varied, socially coordinated play, although outcomes depend on site conditions, detailing, and user mix (Fjørtoft, 2004; Taylor & Kuo, 2009). In this study, we treat biophilic elements as design variables and examine where trees/shade, waterside edges/sounds, and tactile natural materials coincide with changes in occupancy, dwell time, and play modes (see Table 1).

Natural materials and tactile texture (NATMAT): Incorporating wood, rope, and stone increases tactile/kinesthetic variety (grip, edges, temperature, surface friction), which can invite calibrated risk-taking and diversify gross-motor challenges beyond standardized equipment. Prior work links such conditions with broader play repertoires and motor planning in children (Fjørtoft, 2004). In practice, low beams/logs, steppingstones, and boulders can be sequenced to create recombinable movement routes, potentially extending dwell and supporting cooperative/pretend scenarios near these features.

Vegetation and microclimate (VEG). Layered planting that provides canopy shade and seasonal cues contributes to more comfortable microclimates (reduced heat/glare) and to visual/tactile diversity. These settings may support attentional balance and longer episodes of sitting, observing, and imaginative role-play—especially when vegetation loosely defines edges or "outdoor rooms" contiguous with circulation (Kellert & Calabrese, 2015; van den Bosch & Meyer-Lindenberg, 2019). In our maps, shaded greens frequently appeared as hot spots beyond fixed equipment, indicating their anchoring role.

Water features and edges (WATER): Accessible shallow water with audible flow provides salient restorative cues and high sensory richness (visual motion, sound, touch). From an environmental psychological perspective, exposure to nature elements (e.g., water) is associated with stress reduction and attentional restoration (Ulrich, 1984; Kaplan, 1995); from a biophilic design approach such features of water are multi-sensory avenues for connection (Kellert & Calabrese, 2015). For children, waterside edges and shallow, "dippable" features can scaffold sensory exploration (touch/play with water), cooperative tasks, and pretend play, with plausible implications for dwell and social interaction (Fjørtoft, 2004; Taylor & Kuo, 2009; Barton & Pretty, 2010).

Daylight, views, and prospect–refuge: Daylight quality and framed views to natural elements or water, plus a ratio of open prospect versus semi-enclosed refuge can help trigger exploration while maintaining comfort and perceived safety. Shaded prospect lines that overlook play nodes allow parental supervision without crowding the play area, which may reduce interruptions and help maintain episode length (Kellert & Calabrese, 2015; Browning, Ryan & Clancy, 2019).

Layout, connectivity, and inclusivity: The location and relationship of VEG/WATER/NATMAT zones with EQUIP areas will affect the distribution of activity throughout the site. Short, legible paths/thresholds from equipment to shaded greens and waterside edges can convert single-node use into multi-node itineraries (captured by our dispersion indicator). On the other hand, biophilic features that are around the corner or behind long detours may go underutilized even if they are attractive in and of themselves. Inclusive detailing—step-free approaches, tactile cues, nearby shade/seating—supports diverse users and indirectly extends dwell for caregivers and children (Kellert & Calabrese, 2015).

Design-to-indicator link: Framed as evidence-informed choices, biophilic features can be specified to align with measurable outcomes: to extend dwell time, provide canopy shade with adjacent seating and comfortable microclimates; to broaden spatial dispersion, ensure short, legible connections from EQUIP to at least one VEG and one WATER node; and to increase SOCIAL/IMAG, combine tactile NATMAT elements with approachable waterside edges that afford shared tasks and pretend scenarios. These relationships are consistent with biophilia-based mechanisms (restoration, fascination) and child-development correlates (Ulrich, 1984; Kaplan, 1995; Kellert & Calabrese, 2015; Kuo & Taylor, 2004; Fjørtoft, 2004; Barton & Pretty, 2010; Browning et al., 2019; van den Bosch & Meyer-Lindenberg, 2019). (*Emotional states were not directly measured; implications for stress or mood remain inferential.*)

2.4. Biophilic Design and Child Development

Biophilic design, with its natural elements, may support children's cognitive, emotional, and social development. Önder (2013) notes that education in the built environment contributes to students gaining environmental sensitivity and spatial awareness. Children draw satisfaction from their interactions with play environments at very different levels encompasses more than just physical; it is such a vital part of their emotional and cognitive development as well. The workshops and participatory processes of built environment education allow children to bond more strongly with their surrounding environments, which in turn facilitates a more responsible and environmentally aware lifestyle (Önder, 2013). Research has shown that playgrounds designed with biophilic principles lead to improved cognitive development, emotional well-being, and social interactions in children.

As stated by Ünal (2021), "Biophilic design enables children to encounter positive relations with nature, which will strengthen their relationships with the built environment. Exposure to nature is especially important in early childhood, and this study adds to that evidence of fact. Alik (2021) showcased how the integration of biophilic design in healthcare environments not only speeds up recovery and lowers stress levels in children but also highlights the positive physiological and psychological impacts of green spaces. A bibliometric study by Akyıldız (2023) highlighted the increasing research focus on biophilic design in healthcare and educational settings, underscoring its growing importance in promoting child development, as supported by Ünal (2021) and Alik (2021).

2.5. Stress and Mental Health in Children

Psychological responses of children to the perceived challenges or threats are called stress of children. Stress is a protective response to situations that one experiences as threatening, and it has been demonstrated that both acute episodes (like an argument or an exam) and chronic situations (family problems, socio-economic difficulties) lead to anxiety, irritability, and changes in the child mood and behavior. Cortisol is a biomarker of physiological stress; elevations typically indicate higher stress reactivity, whereas reductions are associated with lower stress load and improved affect regulation. (van den Bosch & Meyer-Lindenberg, 2019; Markevych et al., 2017) Poor attachment is one of the most prevalent indicators of cognitive deficiencies and developmentally delayed emotional control that arise from long-term stress exposure (Shonkoff et al., 2012).

Natural elements in parks emit restorative effects on children and help in recovery from mental fatigue and aid our child to cope with stress.

Research shows that children who spend time in parks and green spaces have reduced cortisol levels, indicating lower physiological stress. The natural environment also provides opportunities for non-structured play, which has been highly correlated in literature with the most prominent aspects of coping in children regarding affect regulation and stress relief. Children don't spend all day in these environments but do have the freedom to roam and interact with their environments and others at their own pace, something that fosters independence, creativity, and emotional expression, which helps with stress management (Kuo & Taylor, 2004).

Being in natural environments boosts physical activity (through outdoor play), improves mood, and reduces anxiety and depressive symptoms in children (Barton and Pretty, 2010). Exposure to green spaces and natural designs in parks can decrease stress responses and assist with emotional regulation in children. Those environments not only buffer children from stress but also help them regulate their emotions, increase their ability to pay attention, and develop resilience.

3. BEHAVIOR MAPPING METHOD TO ANALYZE THE FEATURES OF BIOPHILIC PLAYGROUND

Behavior mapping is a useful observational research design that can be applied to help understand movement and interaction among people in each environment. In areas such as playgrounds, where various interactions and activities occur, behavior mapping is a valuable tool to study the impact of biophilic elements—including water, greenery, and natural materials—on children's emotional well-being and stress levels. As well as these biophilic aspects serving to reconnect people to the natural world, research has shown that biophilic design can have calming, restorative, and motivational effects on children (Kellert, S. R., Heerwagen, J. H. and Mador, M. L. (eds.), 2008). Knowing and assessing these effects involves a systematic and data-based approach.

Behavior mapping is the process of charting a region to determine the locations and activities of individuals over a given duration. To examine how children's words and actions connect to biophilic features at the playground, researchers keep track of whether the kids are playing alone, interacting with others, or engaging in active activities. This method provides a useful way to unbiasedly evaluate the relationships between preschool-aged children's physical activity and outside physical settings. This method makes it possible to precisely identify how affordances and contextual elements inside behavior settings affect children's activities when paired with recognized and validated physical activity measurement techniques. Professional groups can use the knowledge obtained from this kind of data to develop policies and recommendations that will guide the design and investment in outdoor childcare facilities. (Cosco et al., 2010)

In biophilic playgrounds, behavior mapping demonstrates how children play with elements such as water, greenery, and natural materials. Similarly, water features attract more attention and promote social interaction (Herrington and Brussoni, 2015). These kinds of observations are so important for understanding the ways that biophilic elements optimize the emotions children experience and support their mental well-being.

Ultimately, behavior mapping offers a powerful lens through which one can examine how biophilic design might help children improve their emotional well-being and reduce stress. Designers, decision-makers, and researchers can use this method's real-time data to inform data-driven decisions about how kids interact with biophilic playground features. Therefore, consistent with physically active use, biophilic playgrounds within our sample may also be related to increased dwell and more social/imaginative play. Although emotional outcomes were not measured directly, these changes in behavior are broadly consistent with previous research suggesting that contact with nature is associated with reduced stress, restored attention and positive effect (Ulrich, 1984; Kaplan, 1995; Taylor & Kuo, 2009; Barton & Pretty, 2010).
We speculate on possible implications for well-being from literature, though it did not measure stress or mood physiologically or through self-report in this study.

3.1. Limitations of Behavior Mapping Method in Analyzing Biophilic Playgrounds

Behavior mapping is a common observational approach to visualize spatial and user behavior in certain environments. Although it offers great insights into its use, its application for assessing biophilic playground features has several limitations. Observational results can be subjectively influenced by risks for both observation and interpretation. For instance, observers might collect more data on some features (e.g., water elements or green spaces) and ignore others. Because of this, the interpretations might be wrong or only show part of the story, especially in more complex settings like biophilic play spaces with lots of natural elements.

Second, short-term observations cannot retain the long-term behavior or phenomena. This approach typically conducts a behavioral mapping of activities at specific times, but it would make it difficult to analyze the long-term impact of biophilic elements on emotional well-being and stress relief on the individual. Biophilic elements in living settings can have very different effects on children depending on things like weather, time of day, or season, so short-term studies can't fully answer this question (Preiser and Schramm, 2017).

Third, a non-qualitative depth is another limitation. This is very valuable in understanding what people are doing and where through behavior mapping but does not reveal why certain behaviors take place or how users react either emotionally or cognitively to biophilic features. For example, seeing children approach the base of a tree does not explain if what attracts them most is the shade, the texture, or the natural aesthetics of the tree. There also will be other forces and variables beyond our control that skew results. Overcrowding, noise, or the presence of caregivers may impact children’s behaviors more than the biophilic features themselves (Woolner, 2010). Ultimately, behavior mapping can be resource dependent. And recording detailed data for long periods and in different environments takes lots of precious time, expert observers, and tools that might not be available.

Given the limitations of behavior mapping, this study is a preliminary exploration and an experimental trial. Complementary methodological approaches are needed to better understand user experience in biophilic playgrounds. These approaches include interviews and surveys to understand how users interact with biophilic elements and their emotional impacts, as well as the use of biological data such as heart rate and skin conductivity to measure stress levels and emotional responses. These approaches can enhance the qualitative and quantitative depth of the data obtained through behavior mapping and help provide a more comprehensive analysis of user experience in biophilic playgrounds.

Overall, though behavior mapping can be an important method for studying spatial behaviors, its limitations—including subjectivity, time limitations, qualitative insight, external influences, and resource demand on study design for capturing displacement behaviors—indicate the potential for complementary methodological approaches, such as investigating user experience through interviews, surveys, or physiological measures, to further understand how biophilic playgrounds impact user experience.

3.2. Sites Selected for Observation

After completing the behavior mapping process, we conducted an in-depth analysis of the parks, specifically focusing on activity hotspots and spatial interactions. Photos that highlighted the parks' characteristics, how users engaged with space, and environmental features further supplemented these analyses. These photographs offered no new information about the parks themselves but added additional context to their useful label and the surrounding text, helping one understand how the various areas of the parks are used and interacted with.

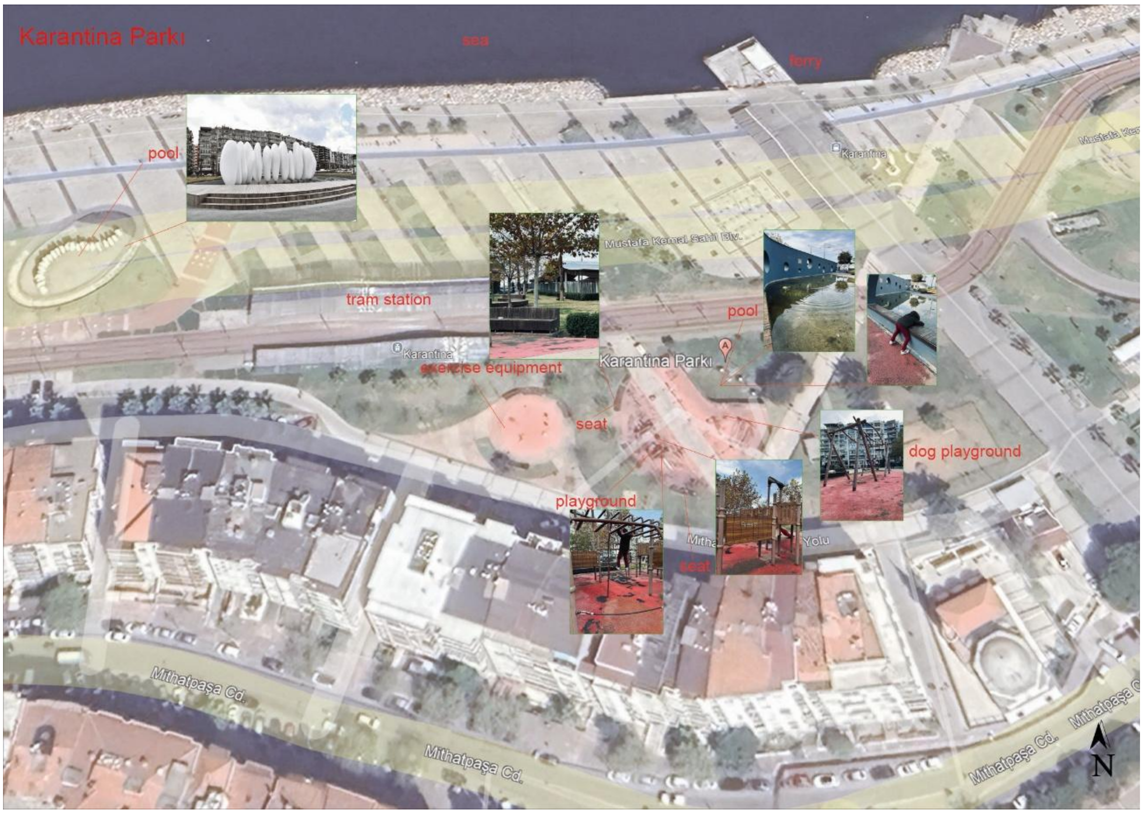

Figure 1. A Park analysis created by processing photographs onto a satellite image of Karantina Park

Karantina Park is a biophilic-designed park, and its play equipment consists of wood and rope. As seen from the photos in Figure 1, the park is designed around the axis of water and natural materials. The park is also directly connected to the sea.

Figure 2. A Park analysis created by processing photographs onto a satellite image of Göztepe Park

Göztepe Park is a traditional, non-biophilic-designed park and it uses plastic for its playground toys. The park, as you can find in the photographs in Figure 2, is designed with artificial materials. Additionally, the playground is located within a parking lot. A nursing home, a neighborhood office building, a supermarket, and a car wash station envelop the playground.

Figure 3. A Park analysis created by processing photographs onto a satellite image of Susuzdede Park

The playground toys in Susuzdede Park are primarily made of wood and rope. Figure 3 illustrates the park's design using natural materials. The park has a high tree density, and there are two playgrounds located within the greenery. The park features natural stone-paved surfaces and stairs. Additionally, there is a designated dog play area.

3.3. Behavior Mapping's Function in This Project

To assess biophilic impact, we implemented a behavior-mapping protocol that links spatial features to observed behaviors on pre-drawn base maps for each site.

Observation schedule and units: Each playground was observed over four consecutive weekends, with one 2-hour session per weekend in the afternoon. Within each session we combined: instantaneous scans every 5 minutes ($t = 0, 5, 10, \ldots, 115$) to record counts by zone and age band; and event-based logging of play episodes with start/stop times and locations.

Spatial reference (scale): Site base maps (≈ 1:500) were subdivided into micro-zones of ~5 × 5 m covering: (i) equipment area, (ii) shaded greens/trees, (iii) waterside edges and immediate surrounds, (iv) paths/thresholds, and (v) open hardscape. All observations were anchored to a micro-zone centroid to enable cumulative density hot-spot mapping.

Coding scheme (what was recorded):
Age bands: 3–6 and 6–9 (visual estimate).
Play modes: SOLO (alone), SOCIAL (peer interaction/cooperation), IMAG (pretend/role-play; can co-occur with SOCIAL), ACTIVE (gross motor: running/climbing/balancing). Co-occurring modes were dual-coded (e.g., SOCIAL + IMAG).
Feature tags: VEG (trees/shade/planting/turf), WATER (fountains/rills/shallow touchable elements; waterside edges/sounds), NATMAT (wood/rope/stone/natural textures), EQUIP (traditional plastic/metal equipment).

Operational definitions (criteria): Interaction with a feature: direct touch or activity within 1 m of the feature for ≥ 10 seconds (e.g., handling water at a rill, balancing on a log, seated play under canopy).
Event (play episode): continuous activity within the same micro-zone without a> 30 s pause or> 3 m displacement. Episode start/stop were logged to compute duration (dwell).

Movement path: displacement> 3 m across micro-zones; sketched as polylines and attributed with the current play mode.

This study involved non-intrusive, anonymized observations of children in public spaces; no identifying information was recorded, and no images were collected. In accordance with institutional policy, formal ethics approval was not required.

Derived indicators (reported in Table 1):
Participation (total n): Unique child count aggregated from 5-minute scans across all sessions.
Median dwell (min): Median duration of play episodes from event logs.
Spatial dispersion (0–1): Index of how widely activity spreads across micro-zones (0 = concentrated on equipment; 1 = broadly dispersed).
Social/imaginary play (%): Share of events coded SOCIAL or IMAG relative to all events.
Off-equipment use (%): Share of events occurring in non-equipment areas (VEG/WATER/NATMAT).

Reliability and constraints: A single trained observer used a written codebook; brief pass-bys (<10 s) were not coded as interactions. Weather and unusual context (e.g., nearby events) were noted in session sheets.

Purpose: This mixed scan + event design quantifies where, how long, and in what modes children engage, allowing feature-specific comparisons between biophilic (VEG/WATER/NATMAT) and traditional (EQUIP) areas and directly producing the indicators summarized in Table 1.

3.4. Fieldwork and Analysis for Playground Behavior Mapping

The study focuses on three well-used neighborhood parks in İzmir—Karantina, Susuzdede, and Göztepe. From December 14, 2024, to January 5, 2025, a trained observer conducted behavior mapping over four consecutive weekends, completing one 2-hour session per site on each weekend (12 sessions in total). All sessions were carried out on weekend afternoons within comparable time windows to minimize diurnal variation.
Observations were recorded on pre-drawn schematic base maps of each playground. For every event, the researcher coded (i) the location (activity node), (ii) the movement path (trace), (iii) the play mode (solo / social / active), and (iv) the age band (3–6 or 6–9). Across weeks, maps were overlaid to generate cumulative density hotspots that spatialize where children clustered, lingered, or dispersed beyond fixed equipment.
To produce the quantitative summary in Table 1, weekly age-band counts on the maps were post-hoc coded and aggregated by site. From these counts we computed (a) total children observed per site across four sessions, (b) the percentage distribution by age band, and (c) per-session intensity (median and mean number of children per 2-hour session). Event-driven anomalies (e.g., short-lived spikes) were noted but did not alter the overall patterns.

Table 1. Summary of four weekend behavior-mapping sessions by playground (İzmir, 14 Dec 2024–5 Jan 2025; 2-hour sessions per site). *Values rounded to one decimal. Median/mean are per-session counts*

Park	Sessions	3–6 (n)	6–9 (n)	Total	% (3–6)	% (6–9)	Median/session	Mean/session
Karantina	4	19	33	**52**	36.5	63.5	12.5	13.0
Susuzdede	4	14	27	**41**	34.1	65.9	10.5	10.25
Göztepe	4	11	10	**21**	52.4	47.6	4.5	5.25

Notes for Table 1.
Median/Mean per session: calculated over the four sessions at each site (2 hours per session).
% by age band: (age-specific total ÷ site total) × 100. The mapping-based figures in Table 1 are used alongside the cumulative density maps (Figures 4-6) to triangulate participation, dispersion, and likely engagement depth. Values rounded to one decimal.

3.5. Results From Behavior Mapping in Selected Playgrounds

As summarized in Table 1, participation is markedly higher in the biophilic playgrounds (Karantina:52; Susuzdede:41) than in the traditional site (Göztepe:21). The biophilic settings also show a greater share of older children (6–9), consistent with the broader spatial dispersion visible in the cumulative density maps (Figures 4-6).

Across the four weekends, activity concentrated beyond fixed equipment in Karantina and Susuzdede, with median session counts of 12.5 and 10.5 children, respectively, versus 4.5 at Göztepe. This quantitative pattern triangulates with the hotspots, which extend into shaded greens and, at Karantina, waterside edges. The prominence of the 6–9 age band in biophilic sites suggests that natural textures and water-proximate zones sustain longer and more socially coordinated play than equipment-only layouts.

The aim of this method was to aid the implementation of the data to explore the correlation of biophilic design (nature-based materials, relationship to play spaces) to the improvement in emotional health and emotional stability and stress reduction in children and to learn whether children were drawn to areas enhanced with biophilic features such as plants, water, and natural materials. The initial observations (round 1) provided information on the general use patterns, while the second round of observations confirmed the use patterns identified.

Schematic maps were generated to illustrate the synthesized data collected from each session at each location post-data collection.

Study-specific constraints—short, weekend-afternoon windows and a single observer—may limit generalizability; broader method limitations are detailed in Section 3.1.

Figure 4. The behavior mapping exercise of first two weeks

Figure 5. The behavior mapping exercise of last two weeks

3.5.1. Illustrative Data from Playground Behavior Mapping

These schematic diagrams illustrate all individual observations recorded in this area throughout a four-week period. More importantly, they represent the spaces preferred by children based on age groups. These diagrams are useful for illustrating the popular, high-traffic areas of a park in contrast with less popular spaces and for categorizing user types, such as children aged 3-6 years or 6-9 years.

In Susuzdede Park and Karantina Park, the busiest areas are playgrounds and surrounding green spaces and water features designed with biophilic materials and biophilic design principles. In contrast, Göztepe Park lacks biophilic elements, and children only spend time in the playground.

The map illustrates children aged 3-6 years (green dots) and 6-9 years (pink dots). The placement of the dots indicates the locations in the park where we observed children. The colored lines represent the movement paths of children within the park.

Figure 6. Four weeks of density

Observational data were collected systematically over a period of four weeks to identify the specific areas in the parks where children spent their time, and these data were overlaid. As seen in Figure 6, by using this method, it was possible to study the patterns of spatial utilization, thus distinguishing zones of high density and low density. This enabled the extraction of the most frequented areas by measuring the cumulative density of activity throughout this period, giving us insight into the behavioral and spatial preferences of the children. This data is useful evidence to analyze how different features in parks (such as playgrounds, green spaces, or biophilic elements) affect usage and what works to attract children of different ages over time.

3.5.2. Space Activation

Cumulative-density hot-spot maps and event logs show that activity at the biophilic sites redistributed beyond fixed equipment into VEG (trees/shade) and WATER (waterside edges) zones, whereas use at the traditional site remained concentrated on EQUIP areas (Figures 4–6). In line with Table 1, median dwell time was higher in VEG/WATER micro-zones than in EQUIP, and the share of SOCIAL/IMAG events was likewise elevated around shaded greens and waterside edges; by contrast, EQUIP clusters were characterized by shorter episodes dominated by ACTIVE codes. NATMAT elements (wood/rope/stone) frequently co-occurred with VEG/WATER nodes and were associated with off-equipment use, indicating that tactile features adjacent to shade and water help sustain cooperative and pretend scenarios. Movement traces at the biophilic sites formed repeated short links between shaded greens and waterside edges—multi-node itineraries rather than single-node occupancy—aligning with higher spatial dispersion values. In the traditional site, trajectories largely radiated to and from EQUIP with limited cross-zone chaining, and overall participation remained lower (Table 1). A single context effect on 29 December (adjacent New Year's bazaar) produced a temporary count increase without altering the baseline activation contrast. Taken together, clustering in VEG/WATER, longer dwell, greater dispersion, and a higher SOCIAL/IMAG share indicate that nature-integrated features coincide with more sustained and socially richer engagement in this three-site comparison.

In order to keep the manuscript concise and figure-led, we do not report site-wise indicator values in a separate table. Instead, we summarize the observable tendencies here, as read from the density and trace maps in the Results section: (i) in biophilic-rich areas, density islands persist longer and span a wider set of micro-cells, suggesting longer dwell and higher dispersion; (ii) play observed away from fixed equipment increases where vegetation, water or natural materials are available; (iii) imaginary/social play concentrates where loose affordances and shaded seating enable small-group occupation. These are behavioral patterns only; emotional outcomes were not measured.

4. CONCLUSION

Across four weekend observation waves in three İzmir playgrounds, sites embedding biophilic features—trees/shade, waterside edges and sounds, and tactile natural materials—were associated with higher participation, longer dwell time, broader spatial dispersion beyond fixed equipment, and a higher share of social/imaginary play relative to the traditional site (Table 1; Figures 4–6). The behavior-mapping approach localized where these differences occurred by producing cumulative-density hot-spots and movement traces, allowing feature-specific interpretation at the scale of zones and edges. While emotional outcomes (e.g., stress/mood) were not directly measured, the observed behavioral shifts are consistent with theorized pathways through which nature contact can support attentional balance and affect regulation.

From a design perspective, these findings point to concrete, replicable features rather than general aesthetics: shaded green areas that invite pause and observation, waterside edges that are audible/approachable, and tactile natural materials (wood/rope/stone) that diversify multisensory and gross-motor affordances. In our observations, biophilic sites sustained engagement beyond fixed equipment and supported more varied, socially coordinated play. By contrast, use at the traditional site remained concentrated on plastic equipment with shorter episodes pattern also visible in the density maps.

Children's play is characteristically exploratory and imaginative. In our sample, the sites offering a broader mix of biophilic affordances exhibited longer dwell, wider dispersion, and more social/imaginary play than the traditional site (Table 1; Figures 4–6). These patterns suggest that a diversity of nature-integrated features may coincide with more sustained and varied engagement in comparable urban contexts. Informal field notes recorded frequent congregation near waterside and shaded green zones even outside equipment use; however, we did not collect physiological or self-report measures of stress or affect, so any emotional interpretation remains inferential.

Taken together, our results align with the broader literature that associates contact with trees, greenery, and natural textures with attentional restoration and affect regulation, but they add spatial specificity: the indicators used here—dwell time, spatial dispersion, and social/imaginary-play ratio—pinpoint *where* design attributes appear to matter within real playgrounds. This evidence can inform (re)design and routine maintenance decisions aimed at extending dwell, broadening activity beyond equipment, and enabling cooperative, imaginative play.

4.1. Implications for future research

Amid increasing urban density and declining everyday contact with nature, our findings—greater participation, longer dwell, broader spatial dispersion beyond fixed equipment, and a higher share of social/imaginary play at the biophilic sites (Table 1; Figures 4–6) —suggest a practical pathway for planning and urban design: prioritize biophilic features that demonstrably coincide with sustained and socially richer engagement. In new developments and park retrofits, this implies anchoring play settings with shaded greens and approachable waterside edges, specifying tactile natural materials (wood/rope/stone), and providing clear connections between equipment areas and biophilic zones so that activity extends and diversifies. These are evidence-informed choices rather than matters of taste, and they can be advanced through collaboration among architects, landscape designers, and community stakeholders to align design intent with neighborhood needs. Methodologically, the present work also illustrates the value of behavior mapping as a flexible, durable people–place technique (see, e.g., Bishop et al., 2024): by pairing site scans with event logs, it yields transferable indicators (dwell time, spatial dispersion, social/imaginary-play ratio) and spatial products (hot-spots, movement traces) that make feature–behavior relationships explicit for practice. Future research should extend observations across seasons and cities, incorporate mixed methods (e.g., brief child/parent interviews), and add affordable physiological proxies (e.g., heart-rate, skin conductance) to test links to stress and emotional health more directly; in parallel, longitudinal designs can probe whether repeated play in biophilic settings influences children's environmental attitudes and stewardship over time, strengthening the generalizability and policy relevance of biophilic playground design.

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