

Design strategies for child-friendly urban outdoor spaces: A narrative approach grounded in parent–child interaction

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ARTICLE INFO	ABSTRACT
<i>Article history:</i> Received March 26, 2026 Received in revised form May 18, 2026 Accepted August 10, 2026 Available online September 01, 2026 <i>Keywords:</i> Child-friendly city Narrative-based spatial organization Parent–child interaction Questionnaire survey *Corresponding author: Jestin bin Nordin School of Housing, Building and Planning, Universiti Sains Malaysia Pulau Pinang, Malaysia Email: jestin.nordin@usm.my ORCID: https://orcid.org/0000-0002-5186-3119	<i>Outdoor public spaces in high-density, mixed-use urban districts are often found to inadequately support parent–child co-presence and interaction. In response, this study develops and evaluates a narrative-based approach to spatial organization for child-friendly outdoor environments through a case study conducted in Future Science City (Changping District, Beijing). A framework of narrative design elements was constructed and integrated with site condition and circulation analyses, while caregiver perceptions were collected through a questionnaire survey of nearby caregivers aged ≥ 18 years and above (valid responses: $N = 99$). The analysis identifies four key design deficiencies: (1) discontinuous pedestrian experiences caused by fragmented routes and isolated activity nodes; (2) functional zoning that fails to accommodate diverse household structures and children's age-specific needs; (3) limited provision for participatory and multisensory interactions; and (4) insufficient attention to child-scale detailing and caregiver-supportive features. Based on these findings, four corresponding design strategies are proposed. Collectively, these strategies form an operational design framework that can be adapted to the renewal of parent–child outdoor spaces in high-density urban environments.</i>

Introduction

Rapid urbanization and changing family structures in China have reshaped daily routines and have altered the frequency, modes, and spatial choices of parent–child outdoor activities. In many cities, extended work hours, academic pressure, and screen-based leisure have reduced opportunities for shared family outings, while children's daily activities have remained strongly contingent on parental involvement (El Nokali, Bachman, and Votruba-Drzal 2010; Zhang, Sun, and Zhao 2017). Public health evidence also indicates insufficient outdoor activity among children and adolescents. The world health organization reported that over 80% of adolescents worldwide do not meet recommended

physical activity levels (WHO 2020), and recent surveys in China suggest that nearly half engage in outdoor activities fewer than three times per week. Against this backdrop, the child-friendly city agenda has become a key policy and planning concern. Child Friendly Cities and Communities Handbook (UNICEF 2018) emphasizes that children's rights to protection, provision, and participation should be supported through inclusive and attractive everyday environments; accordingly, public spaces should be designed not only to be safe and accessible but also to enable children's participation, exploration, and social interaction, while providing families with settings for everyday co-presence and interaction. Prior research suggests that outdoor-space quality, particularly accessibility, safety, diversity, and

sensory richness, is associated with children's play behavior and independent mobility (Kytta, Broberg, and Kahila 2012; Acar 2014). For families, such spaces may also function as informal "third places," where shared activities support parent-child emotional bonding.

Despite growing attention to child-friendly spaces, many urban outdoor environments remain insufficiently responsive to the experiential needs of parent-child interaction. In particular, some sites prioritize basic physical activity yet lack spatial cues that guide shared exploration, emotional exchange, and memory-making. Existing studies offer valuable insights into playgrounds, recreational landscapes, and interactive installations; however, how narrative thinking can structure parent-child experiences in urban outdoor settings, and be translated into implementable spatial strategies, remains underexplored. Moreover, design-oriented research has often remained at a conceptual level, with caregiver-reported emotional experiences and spatial preferences being less systematically incorporated as empirical evidence.

Despite the growing body of research on child-friendly planning and design, three gaps remain in studies addressing urban outdoor spaces for parent-child interaction. First, although narrative theory has been widely applied to environmental experience and spatial storytelling (Austin 2020; Moran, Reilly, and Brady 2021), it has most often been used as a conceptual or interpretive lens. Less attention has been given to explicitly operationalizing narrative as a designable method of spatial organization, for example, by using path sequences, eventful nodes, and rhythmic pacing to guide experience and to activate parent-child co-participation and emotional engagement in everyday urban outdoor settings. Second, child-friendly environment research has frequently prioritized city-scale frameworks, citywide planning, and large parks, thereby establishing key principles related to safety, accessibility, and participation. However, site-specific and implementable strategies for fragmented open spaces in high-density, mixed-use districts remain insufficiently developed. Third, compared with descriptive accounts of children's activity spaces, empirical studies that systematically quantify caregiver perceptions of spatial layout, environmental atmosphere, and interaction opportunities remain limited. As noted by Kervin and Mantei (2022), understanding users lived experiences and meaning-making is

critical for creating resonant environments; this further suggests that more survey-based evidence is needed to support design decision-making. In response to these gaps, narrative thinking and child-friendly design principles were integrated to translate narrative concepts into spatial-organization elements. A case study in Future Science City was conducted, and caregiver questionnaire data were used to identify key experiential needs and preferences. The study aims to propose actionable design strategies for urban outdoor spaces to better support parent-child shared meaning-making, participation, and emotional connection.

Narrative theory and spatial experience

Narrative theory emerged in Western literary studies in the 1960s, where it was initially employed to explain how stories generate and organize meaning. As the field evolved in the late twentieth century, scholarly attention expanded beyond purely temporal structures to include spatial dimensions, giving rise to the so-called "spatial turn" in narrative studies. Within this framework, narrative is understood as an experiential process unfolding not only through time but also through spatial organization. Bakhtin's concept of the chronotope underscores the inseparability of temporal experience and spatial form, suggesting that route sequences, the configuration of nodes, and environmental cues collectively shape the order, rhythm, and meaning of experience (Bakhtin 2020). In a related vein, Foucault argued that physical, social, and symbolic spaces can coexist and overlap within a single site, thereby influencing individuals' psychological perceptions and behavioral patterns (Foucault and Miskowiec 1986). Building on these perspectives, narrative in spatial contexts extends beyond conventional storytelling and is instead embodied in patterns of movement, the interpretation of spatial cues, and the emotional and social responses elicited by the environment. Ryan (2015) further observes that different narrative structures, linear, branching, and open-ended, shape the rhythm of engagement and the depth of experiential involvement. Translated into spatial design terms, a linear narrative organizes key nodes along a primary route, a branching narrative accommodates multiple itineraries tailored to diverse household types and age groups, and an open-ended narrative enables flexible, exploratory spatial networks.

In parent-child outdoor environments, a narrative perspective is particularly valuable because space functions not merely as a passive container for activities but as an active medium that structures continuous experience across movement, pause, and interaction. Through the deliberate sequencing of routes, the strategic placement of nodes, and the design of spatial cues, environments can guide users through coherent experiential trajectories. On this basis, narrative experience is operationalized into four analytical dimensions: (i) route sequencing and experiential pacing; (ii) nodes, landmarks, and spatial markers; (iii) multisensory environmental cues; and (iv) mechanisms that facilitate co-participation between caregivers and children.

Parent-child interaction behavior and child-friendly theories

Parent-child interaction is widely recognized as a critical foundation for children's emotional development, sense of security, and early social competence. Research in developmental psychology indicates that children acquire social understanding primarily through shared activities, imitation, and joint exploration, processes through which trust and emotional bonds with caregivers are gradually established (Kiel and Kalomiris 2015). Outdoor environments provide a particularly important setting for such interactions by enabling greater freedom of movement and spontaneous play, while simultaneously allowing caregivers to engage through accompaniment, guidance, or attentive observation. From this perspective, outdoor parent-child interaction should be conceptualized not merely as a series of discrete behaviors, but as a relational process in which the rhythms of walking, pausing, and play generate opportunities for communication, co-presence, and emotional exchange within the family. Existing studies further suggest that outdoor spaces that are accessible, safe, and visually engaging are more likely to support children's exploratory and cooperative play, while alleviating caregiver burden. In turn, these qualities enhance caregiver responsiveness and sustained participation in children's activities (Karsten and van Vliet 2006).

Child-friendly design theory further underscores the importance of respecting children's physiological and emotional needs while accommodating the diverse patterns of use and interaction among different family members. The core principles of child-friendly spaces are

commonly articulated as safety, accessibility, inclusiveness, and the provision of meaningful opportunities for participation (Elshater 2018). When these principles are applied to everyday, frequently used community outdoor spaces, spatial quality is not determined solely by the presence or quantity of facilities. Rather, it is shaped by how environmental cues are perceived, interpreted, and appropriated by families, for example, whether routes and nodes facilitate shared moments of pause, whether interaction prompts encourage communication and co-participation, and whether spatial atmosphere and fine-grained detailing can sustain parent-child emotional connection over time.

Child-friendly environment and interactive spaces

In contemporary cities, everyday outdoor spaces, such as courtyards, plazas, and neighborhood green areas, are frequently used to support children's exploration and family interaction. In this study, interactive space is defined to encompass both child-environment interaction (e.g., touching, climbing, and exploring) and parent-child interaction arising from shared activities such as accompaniment, cooperation, and communication. Previous research indicates that clear sightlines, legible spatial structures and boundaries, and identifiable environmental cues assist children in distinguishing areas that afford movement, pausing, and play (Stephenson 2003; Woolley and Lowe 2013). Even subtle design features, such as changes in ground texture, low vegetation, or gentle topographic variation, can function as play cues that stimulate imagination, encourage exploration, and enrich children's spatial perception (Scannell and Gifford 2010). For caregivers, such environments can facilitate more manageable forms of accompaniment by allowing guidance or supervision while maintaining visual contact with children (Fjortoft and Sageie 2000). Accordingly, child-friendly interactive spaces should be designed to strike a balance between safety, accessibility, and opportunities for participation. Safety and comfort can be enhanced through appropriately scaled facilities and careful material detailing; accessibility can be supported through continuous and intuitive circulation systems; and interactivity and exploration can be promoted through diverse environmental cues and co-participatory activity nodes. With sustained use, these spaces may evolve into important

settings for everyday family co-presence, thereby creating additional opportunities for parent–child communication and emotional bonding (Ginsburg 2007).

Methods

Parent–child interaction in outdoor public spaces is shaped by multiple spatial attributes, including environmental atmosphere, the organization of activities, and the visual legibility and recognizability of spatial cues. Drawing on the preceding literature review, the key factors influencing parent–child narrative experience are

synthesized into three interrelated categories of design elements: (1) emotional interaction elements, (2) scene and activity elements, and (3) symbolic and narrative cue elements (figure 1). In practice, these elements do not operate in isolation but instead overlap and reinforce one another. Emotional interaction elements provide a stable foundation for companionship, comfort, and shared pausing; scene and activity elements structure parent–child movement and modes of participation; and symbolic and narrative cue elements support spatial cognition and connectivity between activity nodes, thereby collectively enabling a coherent and continuous parent–child outdoor narrative experience.

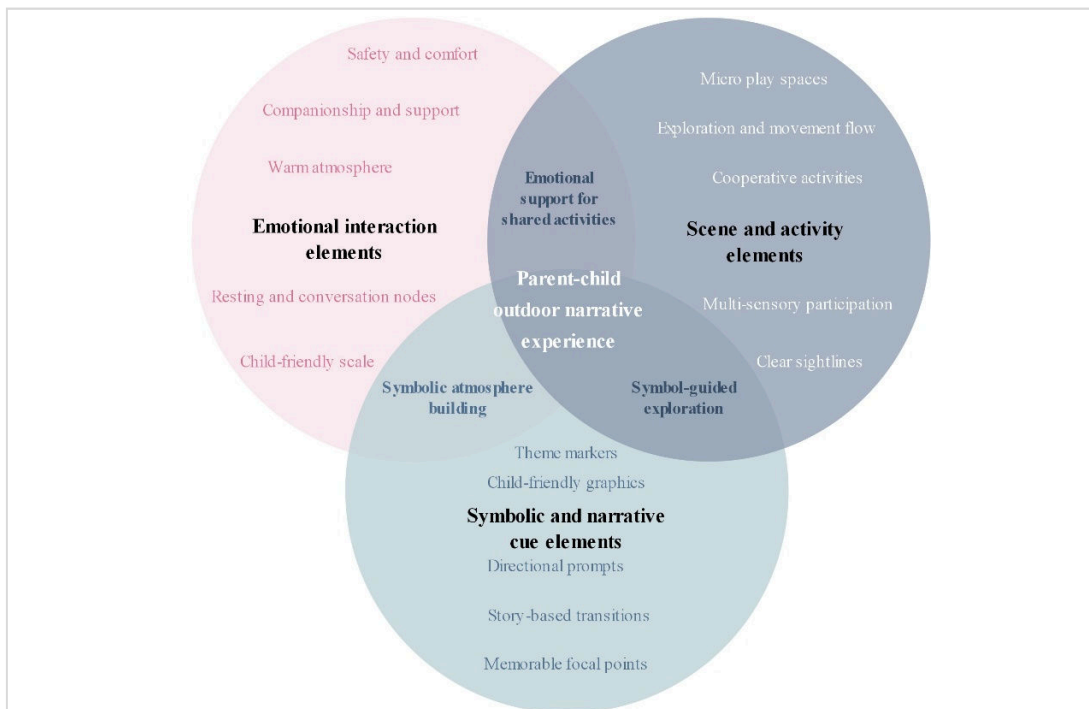


Figure 1. Design elements framework

The first category, emotional interaction elements, focuses on users' subjective experiences, including atmosphere creation, child-scale spatial interfaces, and flexible activity nodes that allow families to pause, converse, and transition smoothly between activities. These elements encourage caregivers and children to slow their pace, maintain co-movement and shared pauses, and communicate within a stable accompaniment process, thereby supporting continuous emotional connection and reassurance.

The second category, scene and activity elements, concerns how spatial configurations facilitate play, exploration, and cooperation. This is reflected in the overall spatial layout, the clarity and distribution of activity nodes, and the continuity and legibility of movement routes. Such structures guide children's engagement across different nodes, while clear sightlines and accessible circulation enable caregivers to supervise, accompany, and respond in a timely manner, thus fostering more natural and sustained shared activities.

The third category, symbolic and narrative cue elements, operates at the level of spatial cognition and interpretation. Theme markers, child-friendly graphics, directional prompts, and story-based transitions provide subtle guidance that helps families understand their location, identify available activities, and perceive the relationships among different nodes. When these cues are organized around a limited number of distinctive visual anchors, they form experience structures that are easier to recognize and recall, thereby enhancing narrative coherence and strengthening place identity.

In addition, the intersections among the three element categories can be conceptualized as follows: (i) emotional and scene elements jointly supporting the emotional dimension of shared activities; (ii) scene and cue elements enabling symbol-guided exploration and smooth transitions between activity areas; and (iii) emotional and cue elements reinforcing atmosphere creation and symbolic continuity. For the subsequent empirical analysis, these three element categories were operationalized through corresponding questionnaire item sets measuring emotional experience (Group B), activity patterns and use (Group C), and symbolic and narrative cues (Group D). These item sets were employed for descriptive statistical analysis and between-group comparisons.

Results and discussion

Site context and urban environment

The study site is situated in the core area of Future Science City in Changping District, Beijing. As one of the city's key innovation-oriented development zones, this area is characterized by a high-density, mixed-use urban fabric. The surrounding environment comprises residential communities, educational facilities, and research and office spaces, reflecting an increasingly family-oriented pattern of community development. Within the policy context of Beijing's child-friendly city initiative, the site was selected as a representative everyday setting for parent-child activities, making it well suited for examining renewal strategies for outdoor parent-child spaces in high-intensity urban environments. As illustrated in [figure 2](#), the case site is well integrated with the surrounding transportation infrastructure and major functional nodes. Its proximity to a rail transit corridor, together with multiple bus routes, forms a primary network for arrival and through-movement, indicating that the site accommodates both pass-through use and stay-oriented activities. The surrounding area is predominantly mixed-use, with relatively concentrated residential and commercial parcels that provide a stable potential user base as well as convenient access to daily services that support parent-child activities. In addition, the site's adjacency to educational facilities and green open spaces suggests that parent-child use is likely to intensify after school hours and during weekends.

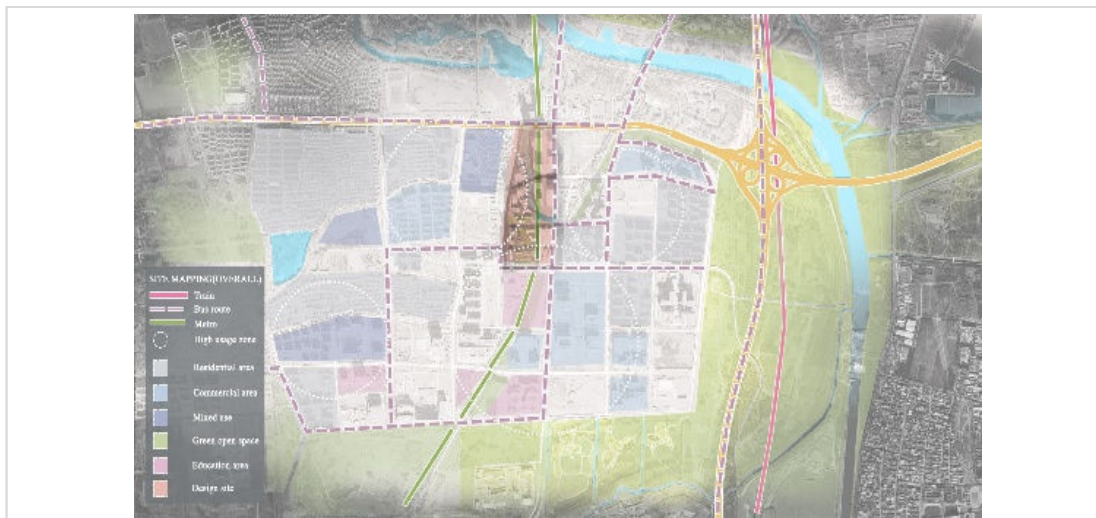


Figure 2. Transport structure and functional distribution of study area

Data collection

An anonymous online questionnaire survey was conducted among caregivers residing in and around the study area to capture family space-use patterns and preference-related needs in urban outdoor parent-child environments. The survey targeted guardians and caregivers aged ≥ 18 years and above who regularly participated in outdoor parent-child activities within the district. A total of 110 questionnaires were collected. Following data screening based on completeness and response-quality criteria, 11 questionnaires were excluded, resulting in 99 valid responses (valid response rate: 90.0%).

Descriptive statistical analysis

The respondents were predominantly parents, with most falling within the 20–29 and 30–39 age groups. The children most frequently

accompanied were aged 7–12 years, followed by those aged 0–6 years (table 1). Multi-generational households constituted the largest proportion of the sample, indicating that grandparents commonly participate in caregiving and accompaniment. As a result, users of parent-child outdoor spaces often comprise both children and older caregivers. Regarding everyday accessibility, most destinations were reached on foot, with travel times primarily concentrated within a 10-minute walk or, secondarily, within 10–20 minutes. This pattern suggests that parent-child outdoor activities depend largely on proximate, routine-use spaces. Consequently, the continuity of pedestrian networks, along with the availability of resting areas and supervision nodes along walking routes, is likely to influence families' willingness to remain in these spaces and their overall experiential quality.

Table 1. Respondent characteristics and participation in parent-child outdoor activities

Note: Multiple responses were allowed for Q4 (child age group[s] accompanied)

Demographic	Frequency	Percentage (%)
Q1 Do you often accompany children in urban outdoor spaces (e.g., parks, green spaces, neighborhood squares)?		
Sometimes	24	24.24
Yes, often	75	75.76
Q2 What is your main role? - Selected Choice		
Grandparent	22	22.22
Other	4	4.04
Parent	73	73.74
Q3 Your age		
20–29	34	34.34
30–39	43	43.43
40–49	5	5.05
50 or above	17	17.17
Q4 The age group(s) of the child you mainly accompany		
0–6 years old	66	66.67
7–12 years old	84	84.85
13–18 years old	21	21.21
Q5 Family structure type		
Middle-aged parents + young child or teenager(s)	17	17.17
Multi-generational household	62	62.63
Other:	1	1.01
Young parents + young child	19	19.19
Q6 Distance from your home to the outdoor space you use most often for family activities		
10–20 minutes on foot	38	38.38
More than 20 minutes on foot	23	23.23
Within a 10-minute walk	38	38.38
Q7 On average, how often do you do outdoor activities with your child per week?		
2–3 times per week	23	23.23
4+ times per week	24	24.24
Less than once per week	18	18.18
Once per week	34	34.34

Overall evaluations of emotional experience were positive, although noticeable variation was observed across individual items (table 2). Items B5 ($M = 3.86$) and B3 ($M = 3.83$) achieved comparatively higher mean scores, indicating that respondents perceived stronger support for parent-child communication and sharing, as well as for child-friendly spatial detailing. By contrast, items B4 ($M = 3.53$) and B1 ($M = 3.58$) received relatively lower ratings, suggesting that aspects

related to overall atmosphere and perceived safety and comfort require further enhancement. In addition, the mean score for B6 ($M = 3.69$) reflects a general consensus that future design interventions should place greater emphasis on reinforcing parent-child emotional interaction. The standard deviations, ranging from approximately 1.06 to 1.14, indicate a moderate level of heterogeneity in respondents' evaluations.

Table 2. Item scores for the emotional experience and comfort module

Demographic	Frequency	Percentage (%)
B1. In these spaces, both my child and I feel safe and at ease	3.576	1.144
B2. There are enough places to rest and talk, so we can stop and communicate easily	3.747	1.072
B3. Details such as the space size, handrails, and steps are child-friendly	3.828	1.107
B4. The overall environment feels warm and relaxing, and it is suitable for family time	3.525	1.137
B5. In these spaces, my child is more willing to talk with me or share feelings	3.859	1.079
B6. I hope future designs can further strengthen parent-child emotional interaction	3.687	1.056

Reported activity patterns and preferred activity conditions are summarized in table 3. Participation in organized activities was the most prevalent behavior (82.83%), followed by light physical activities such as walking, jogging, or cycling (52.53%). In addition, the pattern of children playing with peers while caregivers supervised from nearby locations was also commonly reported (48.48%). With respect to preferred spatial conditions, respondents

expressed the strongest preference for interactive play facilities that support joint family participation (87.88%). This was followed by clearly defined, age-appropriate activity zones (67.68%) and flexible spaces that accommodate both brief pauses and longer stays (62.63%). Other options were selected less frequently, indicating comparatively lower priority among respondents.

Table 3. Outdoor parent-child activity types and preferred activity conditions. Note: Multiple responses were allowed

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Demographic	Frequency	Percentage (%)
Q8What activities do you mainly do with your child in outdoor spaces?		
Walking, jogging, or cycling	52	52.53
Playing on slides, climbing, water play, sand play, etc.	32	32.32
Ball games or other sports together	34	34.34
My child plays with peers while I supervise nearby	48	48.48
Picnicking, chatting, or enjoying the sun	29	29.29
Joining organized activities (parent - child classes, activity days, etc.)	82	82.83
Q9What types of activity conditions would you prefer outdoor family spaces to provide?		
Activity zones for different age groups	67	67.68
Interactive play facilities that families can join together	87	87.88
Continuous and comfortable walking/exploration paths	39	39.39
Moderately challenging exercise facilities (climbing, balancing, etc.)	31	31.31
Flexible spaces for short stops or longer stay	62	62.63

Regarding space-use experience and functional preferences (table 4), items C3 ($M = 4.06$) and C2 ($M = 3.98$) received the highest mean scores, indicating that respondents placed strong emphasis on accommodating diverse household configurations and maintaining a continuous, coherent flow of activities. Item C1

($M = 3.85$) showed a moderate level of agreement, suggesting that opportunities for caregivers to rest while supervising children are generally available, though perceptions vary among respondents. By contrast, C4 ($M = 3.75$) received a relatively lower score, implying that the potential of multisensory experiences to enhance

parent-child interaction has not yet been fully realized in existing outdoor spaces.

Table 4. Item scores for space-use experience and functional preferences

Demographic	Frequency	Percentage (%)
C1. Clear lines of sight help me rest while still keeping an eye on my child.	3.848	1.128
C2. I want the space to have a continuous activity flow, not scattered and disconnected spots.	3.980	1.106
C3. It is necessary to provide different types of spaces for different family structures (e.g., families with young children, multi-generational families).	4.061	1.038
C4. Multi-sensory experiences (light and shadow, water sounds, plant scents, etc.) can clearly improve positive parent - child interaction.	3.747	1.119

Overall ratings for symbolic cues and narrative experience were relatively high, although notable variation was observed across individual items (table 5). Items D3 (M = 4.09) and D2 (M = 4.03) achieved the highest mean scores, indicating strong respondent endorsement of clear wayfinding and directional signage, as well as the enhanced recognizability and memorability afforded by graphic- and color-coded activity nodes. By contrast, D1 (M = 3.88) and D4 (M = 3.85) received comparatively lower

ratings, suggesting that the continuity of thematic cues and the layering of narrative scenes remain underdeveloped in the current spatial configuration. In addition, item D5 (M = 3.99) reflects broadly positive attitudes toward integrating design elements that evoke family memories or holiday-related activities, highlighting the potential value of emotionally resonant narrative features in parent-child outdoor environments.

Table 5. Item scores for symbolic cues and narrative experience

Demographic	Frequency	Percentage (%)
D1. A clear theme or storyline can spark my child's interest.	3.879	1.072
D2. Nodes with graphic or color signs are easier for children to remember.	4.031	1.020
D3. A clear wayfinding system and direction signs are important for both my child and me.	4.091	0.991
D4. Gradual changes in scenes (height, light and shadow, materials, etc.) can create a fun exploration process.	3.848	1.137
D5. I like design elements related to family memories or holiday activities appearing in the space.	3.990	1.098

Based on the overall evaluation and open-ended responses, reported shortcomings were concentrated in four main areas (table 6). First, parent resting and supervision spaces were widely perceived as inadequately planned (85.86%). Second, pathways and circulation systems were frequently described as discontinuous or insufficiently smooth (80.81%). Third, respondents identified deficiencies in safety and protective measures (61.62%). Fourth, activity provisions for different age groups were considered insufficient (59.60%). Although reported less frequently, a substantial proportion of respondents also noted limited interactive or immersive experiences (44.44%) and unclear thematic organization or a lack of memorable

spatial focal points (29.29%). These findings nonetheless indicate that the overall experiential quality of the space remains amenable to further enhancement. When asked to identify priority areas for improvement (with up to three selections permitted), respondents most frequently emphasized the need for multisensory and immersive interactive scenes (79.80%), a greater diversity of activities and facilities (70.71%), and clearer wayfinding, storyline continuity, and landmark recognition (71.72%). In addition, considerable importance was attached to refined human-scale detailing and barrier-free design (68.69%), underscoring the demand for inclusive and carefully calibrated spatial interventions.

Table 6. Reported shortcomings and priority improvement directions

Note: Q10 allowed multiple responses; Q11 allowed up to three selections

Demographic	Frequency	Percentage (%)
Q10 Overall, what shortcomings do you think current outdoor family spaces still have? (multiple choice)		
Not enough safety and protection	61	61.62
Not enough activity content for different age groups	59	59.60
Pathways/circulation feel broken or not smooth	80	80.81
Parent resting and supervision areas are not well planned	85	85.86
Not enough interactive and immersive experiences	44	44.44
The theme is not clear; not memorable enough	29	29.29
Q11 In future child-friendly family outdoor spaces, which three aspects do you most want to improve first? (Select up to 3)		
Emotional atmosphere and companionship experience (sense of safety, comfort, easy to communicate)	28	28.28
Variety of activities and facilities	70	70.71
Themed zones by family structure or age group	34	34.34
Multi-sensory, immersive interactive scenes	79	79.80
Detailed human-scale and barrier-free design	68	68.69
Wayfinding system, storyline, and landmark recognition	71	71.72

Difference analysis

Contingency tables and chi-square tests were employed to examine item-level differences in ratings across caregiving roles and household configurations. The results indicate that statistically significant differences were present for most items by caregiving role and/or household type ($p < 0.05$), suggesting substantial heterogeneity in perceptions of spatial experience among respondent groups. Although the “Other” caregiving role category comprised a relatively small number of respondents, it was retained to ensure analytical transparency; findings associated with this group should therefore be interpreted as indicative rather than conclusive. Accordingly, the discussion focuses primarily on the two dominant caregiver groups, parents and

grandparents, as well as differences across household configurations. Tables 7–12 present the frequency (%) distributions of 5-point Likert-scale responses together with the corresponding chi-square test results.

For B1 (“safe and at ease”), rating distributions differed significantly across caregiving roles ($p = 0.006$) and household configurations ($p = 0.010$) (table 7). Overall, both parents and grandparents tended to report higher ratings, indicating relatively strong perceptions of safety and comfort within the space. At the household level, respondents from multi-generational households were more likely to select higher rating categories, suggesting more favorable assessments of safety and ease compared with other household types.

Table 7. B1 by caregiver role and household type

Demographic	B1. In these spaces, both my child and I feel safe and at ease. (%)					p
	1	2	3	4	5	
Q2What is your main role?						0.006**
Grandparent	4(57.14)	5(55.56)	7(28.00)	3(8.33)	3(13.64)	
Other	0(0.00)	1(11.11)	2(8.00)	0(0.00)	1(4.55)	
Parent	3(42.86)	3(33.33)	16(64.00)	33(91.67)	18(81.82)	
Q5Family structure type						0.010**
Middle-aged parents + young child or teenager(s)	0(0.00)	0(0.00)	1(4.00)	8(22.22)	8(36.36)	
Multi-generational household	5(71.43)	7(77.78)	16(64.00)	21(58.33)	13(59.09)	
Other:	0(0.00)	1(11.11)	0(0.00)	0(0.00)	0(0.00)	
Young parents + young child	2(28.57)	1(11.11)	8(32.00)	7(19.44)	1(4.55)	

For B2 (“enough places to rest and talk”), rating distributions differed significantly by caregiving role ($p < 0.001$), with parents more frequently selecting higher rating categories, indicating greater satisfaction with the availability

of resting and conversation spaces (table 8). In contrast, differences across household configurations were not statistically significant ($p = 0.111$), suggesting that perceptions of rest-and-conversation provision are more closely

associated with caregiving role-specific usage patterns and priorities than with household structure.

Table 8. B2 by caregiver role and household type

Demographic	B2. There are enough places to rest and talk, so we can stop and communicate easily. (%)					p
	1	2	3	4	5	
Q2What is your main role?						0.000***
Grandparent	1(20.00)	3(75.00)	15(50.00)	2(6.25)	1(3.57)	
Other	0(0.00)	0(0.00)	1(3.33)	3(9.38)	0(0.00)	
Parent	4(80.00)	1(25.00)	14(46.67)	27(84.38)	27(96.43)	
Q5Family structure type						0.111
Middle-aged parents + young child or teenager(s)	0(0.00)	0(0.00)	1(3.33)	9(28.13)	7(25.00)	
Multi-generational household	2(40.00)	3(75.00)	20(66.67)	19(59.38)	18(64.29)	
Other:	0(0.00)	0(0.00)	1(3.33)	0(0.00)	0(0.00)	
Young parents + young child	3(60.00)	1(25.00)	8(26.67)	4(12.50)	3(10.71)	

For B3 (“child-friendly details”), rating distributions differed significantly across both caregiving roles ($p = 0.001$) and household configurations ($p = 0.003$) (table 9). Parents were more likely to select higher rating categories, whereas responses from grandparents were more widely dispersed, indicating greater variability in

their perceptions of child-scale details (e.g., handrails and steps) in relation to safety and convenience. Significant differences across household configurations further suggest that evaluations of child-scale detailing are shaped by household context rather than being uniform across families.

Table 9. B3 by caregiver role and household type

Demographic	B3. Details such as the space size, handrails, and steps are child-friendly. (%)					p
	1	2	3	4	5	
Q2What is your main role?						0.001***
Grandparent	1(25.00)	7(70.00)	6(37.50)	6(15.79)	2(6.45)	
Other	0(0.00)	0(0.00)	0(0.00)	4(10.53)	0(0.00)	
Parent	3(75.00)	3(30.00)	10(62.50)	28(73.68)	29(93.55)	
Q5Family structure type						0.003**
Middle-aged parents + young child or teenager(s)	0(0.00)	0(0.00)	0(0.00)	3(7.89)	14(45.16)	
Multi-generational household	2(50.00)	8(80.00)	11(68.75)	27(71.05)	14(45.16)	
Other:	0(0.00)	0(0.00)	0(0.00)	1(2.63)	0(0.00)	
Young parents + young child	2(50.00)	2(20.00)	5(31.25)	7(18.42)	3(9.68)	

For B4 (“warm and relaxing atmosphere”), rating distributions differed significantly across caregiving roles ($p = 0.004$) and household configurations ($p = 0.037$) (table 10). Parents were more likely to report higher ratings for the overall atmosphere, whereas grandparents tended to select lower or more moderate categories, suggesting differences in how comfort and

ambient qualities are perceived or prioritized. At the household level, respondents from multi-generational households exhibited a more concentrated pattern of positive ratings, which may reflect a stronger preference for outdoor spaces that support sitting, lingering, and extended stays.

Table 10. B4 by caregiver role and household type

Demographic	B4. The overall environment feels warm and relaxing, and it is suitable for family time. (%)					p
	1	2	3	4	5	
Q2What is your main role?						0.004**
Grandparent	5(62.50)	4(57.14)	9(31.03)	3(8.57)	1(5.00)	

Demographic	B4. The overall environment feels warm and relaxing, and it is suitable for family time. (%)					p
	1	2	3	4	5	
Other	0(0.00)	0(0.00)	2(6.90)	1(2.86)	1(5.00)	0.037*
Parent	3(37.50)	3(42.86)	18(62.07)	31(88.57)	18(90.00)	
Q5Family structure type						
Middle-aged parents + young child or teenager(s)	0(0.00)	1(14.29)	1(3.45)	9(25.71)	6(30.00)	0.037*
Multi-generational household	6(75.00)	6(85.71)	21(72.41)	15(42.86)	14(70.00)	
Other:	0(0.00)	0(0.00)	1(3.45)	0(0.00)	0(0.00)	0.037*
Young parents + young child	2(25.00)	0(0.00)	6(20.69)	11(31.43)	0(0.00)	

For B5 (“child more willing to talk/share feelings”), rating distributions differed significantly across caregiving roles ($p = 0.025$) and household configurations ($p = 0.012$) (table 11). Parents were more likely to report higher ratings, suggesting that enhanced child willingness to communicate is more readily perceived during parent–child outdoor activities. In contrast, responses from grandparents were

more neutral and dispersed, indicating greater variability in perceived communication willingness. At the household level, respondents from multi-generational households more frequently selected higher ratings, which may reflect increased opportunities for interaction and emotional responsiveness within multi-caregiver accompaniment contexts.

Table 11. B5 by caregiver role and household type

Demographic	B5. In these spaces, my child is more willing to talk with me or share feelings. (%)					p
	1	2	3	4	5	
Q2What is your main role?						0.025*
Grandparent	0(0.00)	4(44.44)	8(40.00)	9(26.47)	1(3.03)	0.025*
Other	0(0.00)	1(11.11)	0(0.00)	2(5.88)	1(3.03)	
Parent	3(100.00)	4(44.44)	12(60.00)	23(67.65)	31(93.94)	0.012*
Q5Family structure type						
Middle-aged parents + young child or teenager(s)	0(0.00)	0(0.00)	2(10.00)	4(11.76)	11(33.33)	0.012*
Multi-generational household	1(33.33)	5(55.56)	13(65.00)	25(73.53)	18(54.55)	
Other:	0(0.00)	1(11.11)	0(0.00)	0(0.00)	0(0.00)	0.012*
Young parents + young child	2(66.67)	3(33.33)	5(25.00)	5(14.71)	4(12.12)	

For B6 (“future designs should strengthen parent–child emotional interaction”), rating distributions differed significantly across caregiving roles ($p = 0.030$) and household configurations ($p = 0.001$) (table 12). Parents expressed stronger agreement regarding the need to enhance parent–child emotional interaction, whereas grandparents also reported generally

positive attitudes but with comparatively lower intensity. Notably, expectations were most pronounced among respondents from multi-generational households, suggesting that future design interventions should better accommodate interactive scenarios that support co-participation among multiple caregivers.

Table 12. B6 by caregiver role and household type

Demographic	B6. I hope future designs can further strengthen parent–child emotional interaction. (%)					p
	1	2	3	4	5	
Q2What is your main role?						0.030*
Grandparent	3(60.00)	3(50.00)	7(25.93)	9(23.68)	0(0.00)	0.030*
Other	0(0.00)	1(16.67)	1(3.70)	1(2.63)	1(4.35)	
Parent	2(40.00)	2(33.33)	19(70.37)	28(73.68)	22(95.65)	0.030*

Demographic	B6. I hope future designs can further strengthen parent–child emotional interaction. (%)					p
	1	2	3	4	5	
Q5Family structure type						0.001**
Middle-aged parents + young child or teenager(s)	0(0.00)	0(0.00)	2(7.41)	10(26.32)	5(21.74)	
Multi-generational household	3(60.00)	5(83.33)	18(66.67)	18(47.37)	18(78.26)	
Other:	0(0.00)	1(16.67)	0(0.00)	0(0.00)	0(0.00)	
Young parents + young child	2(40.00)	0(0.00)	7(25.93)	10(26.32)	0(0.00)	

Taken together, differences associated with caregiving roles and household configurations underscore the importance of inclusive outdoor environments that accommodate both parent- and grandparent-led caregiving. In particular, such spaces should prioritize safe and comfortable resting areas, along with appropriately scaled child-friendly detailing, to support diverse caregiving practices and intergenerational co-presence.

Existing conditions and key issues

1. Fragmented circulation and lack of a continuous parent–child experience path
Under existing conditions, the pedestrian system primarily prioritizes commuting and transfer efficiency, relegating parent–child activities to fragmented residual spaces. Consequently, a coherent experiential sequence, encompassing arrival, pausing, observation, play, and rest, is rarely realized. Survey results reinforce this observation: respondents expressed a strong preference for continuous and comfortable walking and exploration routes, and frequently identified disrupted circulation and insufficient interactive experiences as major deficiencies. Immersive and participatory features were also consistently highlighted as priorities for improvement. Overall, discontinuities in circulation and experiential continuity constitute a key constraint on the quality of parent–child interaction in the study area.
2. Limited space typologies and inadequate functional zoning for diverse household configurations
Field observations indicate that the existing environment is largely characterized by undifferentiated plaza spaces and basic 设施, with a notable lack of mixed-use micro-settings capable of simultaneously supporting play, social interaction, and co-participation. Consistent with the survey findings,

respondents expressed a clear demand for age-specific activity spaces and emphasized that future environments should better accommodate differentiated patterns of use across diverse household configurations. Together, these results suggest that insufficient typological diversity not only limits the spectrum of activities available but also constrains opportunities for families to engage in shared and sustained interaction.

3. Insufficient caregiver resting and supervision support

Effective parent–child use of outdoor spaces depends not only on the range of activities available to children but also on caregivers' ability to rest comfortably, maintain clear sightlines, and remain actively engaged. At present, resting facilities and supervision points are often insufficient in both quantity and spatial placement. Inappropriate distances and poor visual connections between seating areas and activity zones hinder caregivers' ability to balance rest with effective supervision during accompaniment. Consistent with these observations, survey results indicate relatively high levels of dissatisfaction with existing resting and supervision provisions, suggesting that this shortcoming is widespread and plays a decisive role in shaping overall space-use experience.

Research on design strategies for child-friendly parent-child spaces

a. Integrating urban structures to shape narrative routes

Building on the site analysis and user needs, the dispersed open spaces within the site were reconfigured into a continuous, narrative-oriented slow-mobility system aligned with existing transport and pedestrian-flow structures. Prior to the intervention, accessible spaces were fragmented, and parent–child

activities were often confined to residual corners and vacant patches, with limited spatial organization to support sustained pausing and interaction. To address this condition, an elevated walkway was introduced to traverse the site, transforming routine pass-through movement into an experiential parent-child walking sequence. Along the route, five circular platforms were positioned as key nodes for pausing, viewing, play, and rest; transitions between nodes were supported through stairs, pocket plazas,

planting areas, and water features that provide intermediate stopping conditions. The elevated configuration reduces conflicts with ground-level traffic and reinforces a visual narrative rhythm by strengthening continuity among buildings, streets, and open spaces. Overall, through route continuity, rhythmic node placement, and sightline organization, this strategy reframes movement that was primarily pass-through as a shareable parent-child experience (figure 3).

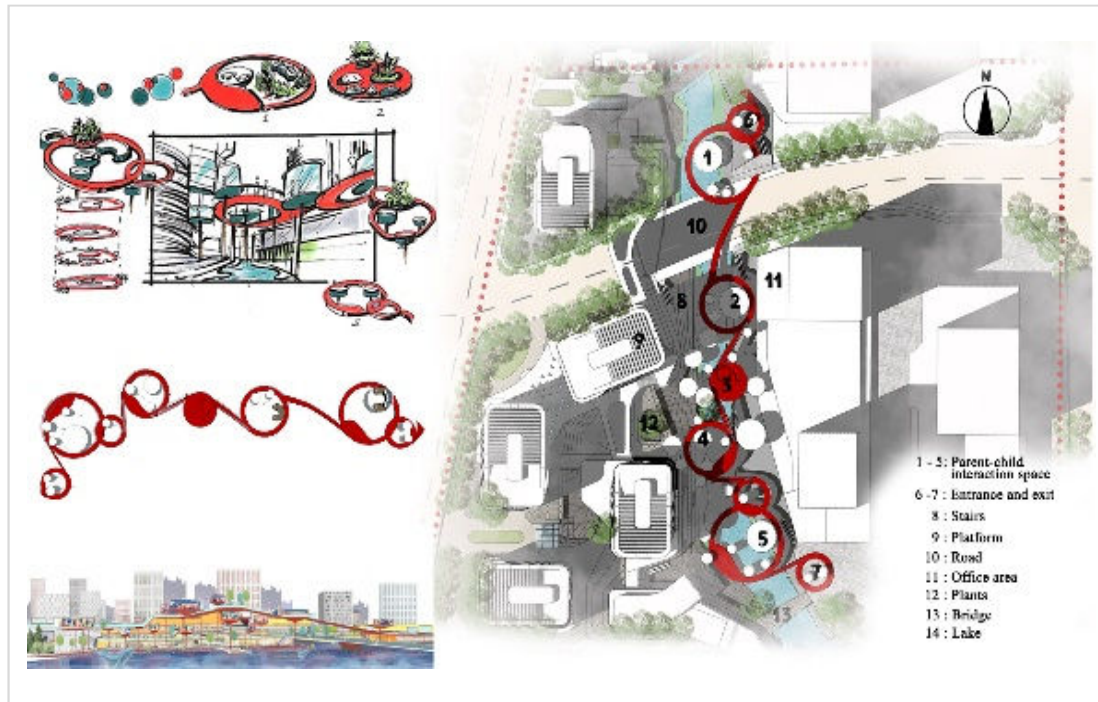


Figure 3. Overall site plan

b. Designing themed areas for diverse family structures

Child-friendly outdoor spaces should not rely solely on adding facilities; instead, they should be designed to accommodate differences in activity intensity, dwelling patterns, and supervision needs across household configurations. Informed by the survey findings and prior studies (Moore and Young 1978; Ginsburg 2007), typical users were categorized into four groups. Expectations varied across groups: families with young children tended to prefer shared play and developmental activities; families with school-aged children or adolescents emphasized exploration with a degree of

autonomy; grandparent-led caregiving placed greater value on comfortable, safe, and easy-to-supervise resting settings; and multi-generational households required flexible scenes that accommodate multiple age groups. Accordingly, five themed areas were proposed (figure 4): an interactive play zone, an immersive exploration zone, a social interaction zone, a relaxation and restoration zone, and a horticultural experience zone that supports multi-generational co-participation. Through a combined “zoning + nodes” spatial logic, differentiated support for diverse household configurations can be delivered within a shared site.

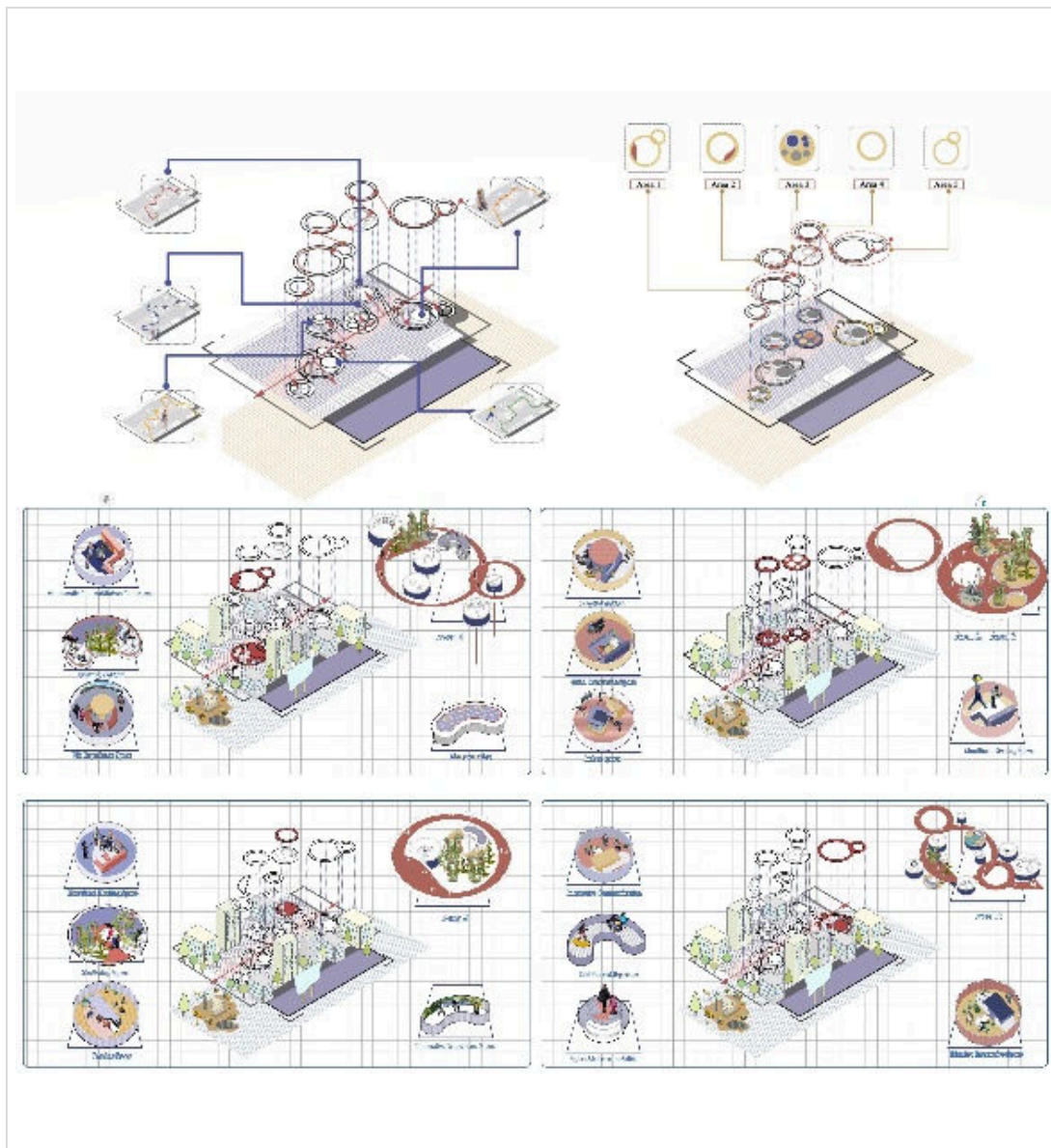


Figure 4. Mapping of family structures to corresponding spatial zones

c. Enhancing parent–child interaction through immersive scenes

In many urban public spaces, parent–child use remains largely supervision-oriented, with limited experiential supports that facilitate co-exploration and more balanced participation. To address this gap, an immersive scene system was introduced. Through coordinated orchestration of imagery, lighting, soundscape, and spatial sequencing, an interactive experience that families can enter together was constructed. Specifically, panoramic projection, responsive lighting,

immersive audiovisual installations, and interactive flooring were integrated, together with tactile interfaces that provide action-based feedback. This configuration enables a continuous participation process through movement, pausing, and hands-on engagement. The system structures experiential rhythm through a “narrative nodes–transitions” logic, guiding families to move between nodes for observation, interaction, and communication, thereby reframing supervision-based use into co-participatory activity (figure 5).

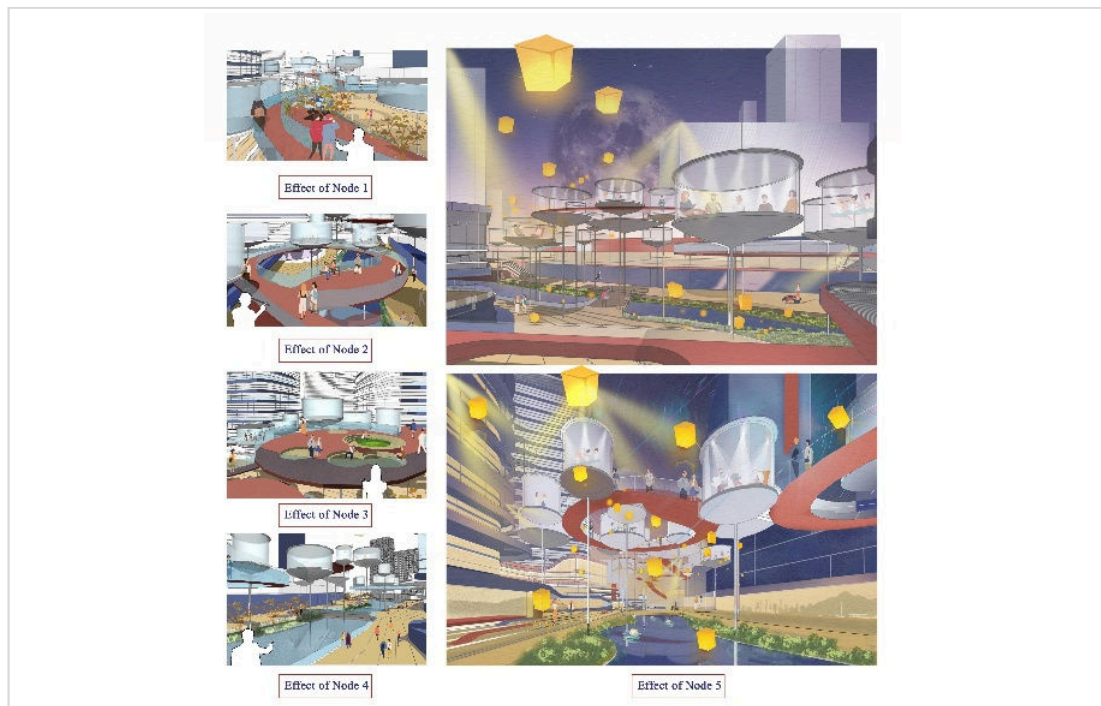


Figure 5. Effect of the spatial node

d. Optimizing interaction through human-centred design

While immersive experiences and spatial narrative can enhance engagement, inclusive performance depends on careful attention to age-diverse users' physical comfort and accessibility. Three design controls were emphasized: posture-related ergonomics, social distance management, and multi-layer accessibility. At the ergonomic level, the space was designed to support common

postures, sitting, squatting, leaning, and walking, while accounting for differences in stature and mobility across adults, children, and older users. Key nodes were therefore specified with safe, stable, and pause-friendly interfaces. At the social-distance level ([figure 6](#)), node spacing and inter-visibility were calibrated to maintain continuous supervision while reducing crowding that may interrupt interaction.

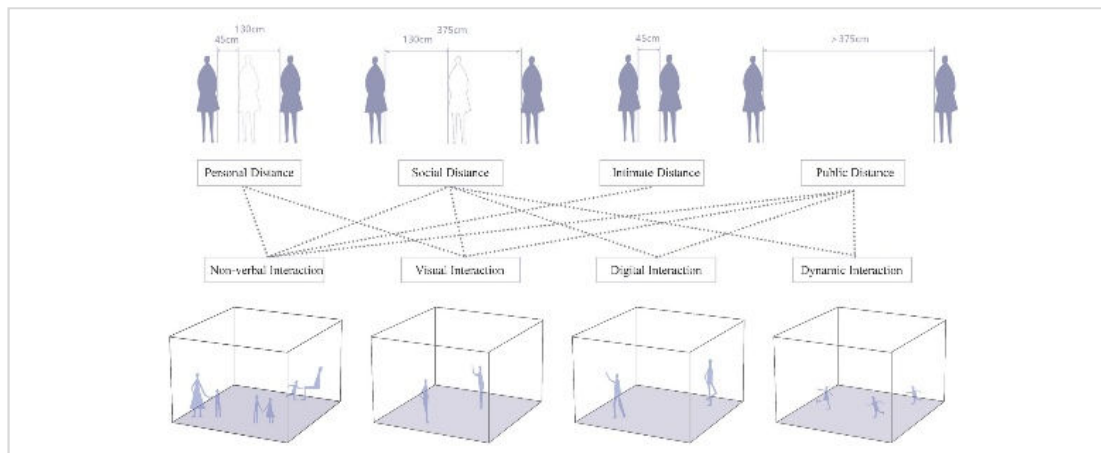


Figure 6. Social-distance principles supporting parent-child interaction

Conclusions

Future Science City was selected as a case study to examine the design logic of child-friendly parent-child outdoor spaces from a narrative perspective. Drawing on site and circulation analyses combined with a caregiver questionnaire survey; three core issues were identified. First, pedestrian routes and pause nodes were highly fragmented, causing parent-child activities to be frequently disrupted by pass-through movement. Second, spatial typologies and functional organization were limited in diversity, constraining adaptability to children of different age groups and to varied household configurations, including multi-generational families. Third, deficiencies in multisensory engagement, child-scale detailing, and caregiver-oriented resting and supervision facilities reduced both the frequency and continuity of parent-child interaction. In response to these challenges, four interrelated spatial strategies were proposed. (1) A continuous walking system was reorganized to establish a legible narrative route, structured by a coherent sequence of activity and pause nodes that support interaction and co-presence. (2) Thematic zoning was introduced to better accommodate diverse age groups and household configurations. (3) Participatory, multisensory activity scenes were incorporated to encourage co-exploration and strengthen emotional engagement between caregivers and children. (4) Human-centred spatial detailing, including ergonomic design, sightline optimization, and barrier-free provisions, was emphasized to enhance accessibility, supervision, and overall user comfort. The primary contribution of this study lies in translating abstract narrative concepts into a set of operational spatial elements, thereby offering a practical methodological framework for the renewal of parent-child public spaces in high-density urban environments. Nevertheless, several limitations should be acknowledged. The findings are based on a single case study and a relatively modest sample size. Future research should apply and test the proposed framework across multiple urban contexts and further triangulate questionnaire data with behavioural observations and longitudinal evaluations to assess long-term use and experiential outcomes.

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Author(s) contribution

He Xueqian contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Jestin bin Nordin contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

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