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The evolution of visualisation tools of Chinese children's sign systems: Semiotic aspect

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Abstract. The relevance of this study lies in examining how child-oriented wayfinding in public spaces shifted from basic safety measures to culturally and emotionally charged mediators amid changing standards, policies, and digital technologies. This study aimed to investigate the evolution of visualisation tools in Chinese children's sign systems from a semiotic perspective. Drawing on Bronislaw Malinowski's cultural stratification theory, the research combined diachronic analysis of national and local standards, policy documents, and representative cases from children's hospitals, kindergartens, theme parks, and cultural venues. A semiotic-stratification approach was applied to interpret changes at three levels: material apparatus, institutional regulation, and spiritual-emotional meanings, highlighting links between visual codes and broader sociocultural transitions. The findings identified three historical phases in the evolution of Chinese children's sign systems: a Safety-Dominant phase (1983-2008) characterised by standardised pictograms, high-contrast colours, and warning semantics; a Cultural-Consciousness phase (2009-2018) that incorporated regional motifs, local food symbols, and intangible heritage elements to reconstruct identity and reduce anxiety; and a Digital-Intelligence Innovation phase (2019-present) that integrated augmented reality, IoT, and interactive interfaces to create multisensory, affective guidance experiences and data-informed spatial management. Taken together, the semiotic-stratification analysis showed that standardised safety grammars, culturally embedded visual identities, and digitally mediated multisensory interfaces accumulated rather than simply replaced one another over time, revealing the co-evolution of design practice with policy agendas and social expectations. The findings offer conceptual implications for child-friendly city initiatives and for future wayfinding design that considers both technological innovation and the continuity of local cultural narratives

Keywords: wayfinding system design; child-friendly environments; cultural stratification theory; visual communication design; emotional experience

INTRODUCTION

Children's sign systems in China are not only instruments of navigation and safety but also mediators in cognitive development, cultural cultivation, and social integration. In everyday environments, they help children build spatial awareness and a sense of security while gradually developing symbolic cognition. At the same time, these systems embed cultural motifs and aesthetic traditions, enabling children to form identity and belonging through routine interactions with public

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spaces. In the context of rapid urbanisation and digital transformation, child-oriented wayfinding must reconcile basic safety, age-appropriate cognition, and locally grounded cultural narratives within increasingly complex built environments.

In parallel with these practical demands, research on wayfinding and visual communication expanded along several interdisciplinary trajectories. V. Mehta & C. Auffrey (2022) demonstrated that wayfinding in complex urban environments involved balancing legibility with place-based identity, showing that signage functioned not only as navigational infrastructure but also as a mediator of spatial meaning. V. Manchia (2022) situated signage and information design within debates on environmental and sustainable communication, and emphasised that public visual systems responded to ecological and social responsibilities rather than purely instrumental demands. Semiotic and visual communication studies deepened this perspective by treating pictograms and graphical interfaces as cultural codes rather than neutral information carriers. G. Aiello (2020) argued that visual communication in public environments was embedded within power relations and cultural hierarchies, and that signage participated in the negotiation of visibility, identity, and belonging. S. Jamshidi & D. Pati (2024) complemented this view by analysing how contemporary public information symbols balanced international standardisation with local adaptation, thereby foregrounding the semiotic tensions between global norms and culturally specific meanings in complex wayfinding systems.

From a cognitive perspective, studies examined how children interpreted iconic and multimodal cues in learning and navigation contexts. Y. Motamedi *et al*. (2024) found that degrees of iconicity and redundancy in visual symbols shaped children's ability to infer meaning from unfamiliar signs, suggesting that symbol design needed to align with developmental stages of symbolic cognition. O. Bock *et al*. (2024) highlighted how visual attention and strategy use influenced children's search and wayfinding behaviour in complex visual displays, pointing to the importance of cue salience, layout, and task structure. In addition, Z. Qiu *et al*. (2025) showed that audio-visual temporal integration affected perceived continuity and user comfort in dynamic environments, indicating that multisensory guidance systems required careful calibration for different age groups.

Within the Chinese context, scholars began to address user diversity and spatial complexity through interdisciplinary integration and system-level thinking. Z.Y. Lu & X.J. Zhan (2024) analysed wayfinding in mega-structures and transport hubs through spatial hierarchy and behavioural patterns, demonstrating that signage systems adapted to multi-layered circulation networks and varied user expectations. W. Huang *et al*. (2023) discussed how Chinese wayfinding projects increasingly combined branding, cultural storytelling, and service design, reflecting a shift from purely functional markers toward behaviourally and culturally meaningful guidance systems. Earlier work also noted the relevance of cultural specificity and large-scale planning perspectives in signage and wayfinding, but these accounts did not provide a sustained, child-focused semiotic explanation of how such systems evolved in China.

Despite these advances in research and policy, recent national guidelines for child-friendly cities and communities also underscored the need to align public-space design with children's developmental characteristics and rights to participation (Ministry of Housing and Urban-Rural Development, 2022; China Association for Community Development, 2024). However, research on child-oriented sign systems in China still showed two gaps. First, few studies offered a diachronic semiotic account of how children's signage evolved alongside cultural change, technological development, and urban policy, from early public-information standards to current digital-intelligent environments. Second, this historical evolution rarely was interpreted through Bronislaw Malinowski's tripartite cultural stratification – material apparatus, social institutions, and spiritual life – to explain how safety functions, institutional codes, and emotional-cultural meanings were layered in children's visual communication. Against this backdrop, the present article aimed to trace the evolution of Chinese children's sign systems from the 1980s to the present, to interpret this trajectory using Malinowski's cultural stratification theory, and to outline an analytical perspective linking safety, cultural identity, and emotional experience in the design of child-oriented wayfinding systems.

MATERIALS AND METHODS

This study adopted a qualitative, diachronic research design to examine the evolution of China's child-oriented sign systems from the 1980s to 2025. Grounded in a semiotic perspective and drawing on B. Malinowski's (1944) theory of cultural stratification, the research focused on how children's sign systems shifted from purely functional safety tools to carriers of cultural identity and emotional experience. Within this theoretical framework, Malinowski's tripartite structure of "material apparatus – social institutions – spiritual life" revealed the interactive logic between technological iteration and cultural praxis. Applied to children's wayfinding systems, the material stratum emphasised physical carriers and visual syntax, focusing on the implementation of safety functions. The institutional stratum concerned sign conventions and cultural semantics, demonstrating how design languages embed regional cultural elements. And the spiritual stratum highlighted emotional resonance and value identification, reflecting the functional transition from information transmission to emotional empowerment.

For empirical analysis, twenty-six representative cases of child-oriented sign systems were selected, including kindergartens, hospitals, theme parks, and

museums. These cases were chosen for their visibility in public design discourse, the availability of visual and textual documentation, and their coverage of different facility types and historical phases. While the full case set informed the identification of phase-typical patterns, only six particularly illustrative cases are discussed in detail to avoid overburdening the Results section. The broader corpus serves as a reference for general trends and recurring design elements. In parallel, the study reviewed a diachronic set of normative and policy documents to establish the regulatory and institutional context in which children's sign systems evolved. The corpus included national standards and technical guidelines, as well as technical drafting guidance focused on child safety and relevant local standards (Standardisation Administration of China, 1983; 1988; 1994; 2008a; 2008b; 2008c). Where applicable, an international reference standard was consulted (International Organisation for Standardisation, 1980). The policy set covered cultural-industry and cultural-service documents (General Office of the State Council of the People's Republic of China, 2009) and child-friendly urban construction (Shanghai Municipal People's Government Office, 2021). Representative municipal programmes were also reviewed to contextualise digital-infrastructure implementation. All cited documents were consolidated in Table 1.

Table 1. Major standards and policy documents shaping the evolution of child-oriented sign systems in China

Phase	Year	Standard / policy document	Issuing body
Safety-dominant phase	1983	GB 3818-1983 Public Information Graphical Symbols	Standardisation Administration of China
	1988	GB 10001-1988 Graphical Symbols for Public Information Signs	
	1994	GB 10001-1994 Graphical Symbols for Public Information Signs	
	2008a	GB 2894-2008 Safety Signs and Guidelines for Use	
	2008b	GB/T 7291-2008 Technical Guidelines for Graphical Symbols Based on Consumer Needs	
	2008c	GB/T 20002.1-2008 Drafting for Special Aspects in Standards – Part 1: Child Safety	
	2020	DB54/T 0226-2020 (local standard for child welfare institutions)	Tibet Autonomous Region Administration for Market Regulation
Cultural-consciousness phase	2009	Cultural Industry Revitalisation Plan	State Council of the People's Republic of China
	2011	Decision on Deepening Cultural System Reform	
	2012	The Ministry of Culture's Twelfth Five-Year Plan for Doubling Cultural Industries	Ministry of Culture of the People's Republic of China
	2015	Guidelines on Accelerating Modern Public Cultural Service Systems Ministry of Culture of the People's Republic of China	State Council of the People's Republic of China
	2016	Opinions on Promoting Cultural Creative Product Development	
Digital-intelligence phase	2019	Guiding Opinions on Promoting the Deep Integration of Culture and Science and Technology	Publicity Department of the CPC Central Committee, Cyberspace Administration of China, Ministry of Finance, Ministry of Culture and Tourism, National Radio and Television Administration
	2021	14th Five-Year Plan (2021-2025)	National People's Congress of the People's Republic of China
	2022	Guidelines for Child-Friendly City Construction (revised)	Ministry of Housing and Urban-Rural Development / China Association for Community Development
	2021	Digital infrastructure and smart-city action plans (Beijing)	Beijing Municipal Bureau of Economy and Information Technology
	2021	New infrastructure and digital transformation plans (Shanghai)	Shanghai Municipal People's Government Office

Source: compiled by the authors based on Standardisation Administration of China (1983; 1988; 1994; 2008a; 2008b; 2008c), Tibet Autonomous Region Administration for Market Regulation (2020), General Office of the State Council of the People's Republic of China (2009; 2016), The State Council of the People's Republic of China (2011), Ministry of Culture of the People's Republic of China (2012), National People's Congress of the People's Republic of China (2021), Ministry of Housing and Urban-Rural Development (2022), China Association for Community Development (2024), Beijing Municipal Bureau of Economy and Information Technology (2021), Shanghai Municipal People's Government Office (2021)

Analytically, the investigation proceeded in three steps. First, the normative documents and case materials were aligned diachronically to identify periods of concentrated regulatory change and corresponding shifts in design practice. Second, Malinowski's tripartite cultural stratification – material apparatus, social institutions, and spiritual life – was applied as an interpretive lens to organise observations across cases and documents. Specifically, the material stratum addressed changes in sign carriers and visual grammars (e.g., pictogram form, colour/contrast strategy, layout, and ergonomic visibility); the institutional stratum addressed standardised requirements and organisational logics embedded in wayfinding (e.g., information hierarchy, compliance constraints, and service-flow cues); and the spiritual-emotional stratum addressed affective and identity-related meanings in children's experience (e.g., reassurance, cultural belonging, and participation cues). Third, cross-case comparison of these observations supported the identification of phase-typical configurations and the delineation of three analytical phases – Safety-Dominant, Cultural-Consciousness, and Digital-Intelligence Innovation.

RESULTS AND DISCUSSION

The analysis identified three phases in the evolution of child-oriented signage design in China from the early 1980s to 2025: a Safety-Dominant Phase (1983-2008), a Cultural-Consciousness Phase (2009-2018), and a Digital-Intelligence Innovation Phase (2019-present). Overall, the Safety-Dominant Phase established a standardised, safety- and risk-oriented visual grammar; the Cultural-Consciousness Phase reoriented signage towards place identity and cultural storytelling; and the Digital-Intelligence Innovation Phase extended these layers through responsive, multimodal media. Rather than mapping neatly onto calendar decades, the periodisation synthesises recurring shifts in dominant design priorities, visual/material strategies, and the ways children are positioned as users within public sign systems. The boundaries between phases were inferred from converging evidence in the diachronic corpus of standards/policies and the selected cases, especially shifts in safety standardisation (1983-2008), cultural-policy orientation (from 2009), and culture-technology integration and child-friendly city agendas (from 2019).

Safety-Dominant Phase. Historically, child-related signage in China developed alongside the broader standardisation of public information symbols. During the early period of the People's Republic of China (1949-1978), public environmental signage received limited attention and remained largely unsystematic (Shen *et al*., 2019). Following the Reform and Opening-Up policy, accelerated economic globalisation and social change generated demand for rationalised graphical languages in public spaces. National standards such as GB 3818-1983 and the subsequent GB 10001 series gradually consolidated pictograms and usage rules for core public facilities (Standardisation Administration of China, 1983). Reviews of the GB/T 10001 series also documented how these standards expanded through later revisions (Zhang, 2007). Later safety standards, notably GB 2894-2008, and local derivatives such as DB54/T 0226-2020**,** extended requirements for warning content, placement, and visibility into children's activity spaces (Standardisation Administration of China, 2008c; Tibet Autonomous Region Administration for Market Regulation, 2020).

The analysis of early child-related environments shows that these standards established a prototypical safety paradigm based on high-contrast chromatic schemes, simple geometric configurations, and concise pictograms. Standardisation prioritised functional orientation and aligned with widely used principles of simplicity and recognisability articulated in ISO 7001:1980 *(International Organisation for Standardisation, 1980).* In practice, children were not addressed as a distinct user group, yet their presence was implicitly acknowledged through symbols such as "priority seating for passengers with children" and "slippery surface warnings" in circulation spaces. In children's hospitals and kindergartens, designers typically derived child-facing signs by scaling, recolouring, or slightly softening existing safety pictograms while retaining their normative semantics. This pattern positioned children primarily as vulnerable subjects who had to be protected from specific risks, and it framed sign systems as instruments for clearly signalling danger and appropriate behaviour rather than as media for participation (Fig. 1).

A second configuration identified in the case corpus concerns the integration of ergonomic and perceptual parameters. With the expansion of the GB/T 10001 series and the introduction of GB/T 7291-2008 and GB/T 20002.1-2008, guidelines began to incorporate consumer needs and child safety into technical drafting criteria (Standardisation Administration of China, 2008a; 2008b). In analysed projects such as Suzhou Xinzhou Kindergarten, the Children's Hospital affiliated with Zhejiang University School of Medicine, and Beijing Happy Valley, sign installation heights were typically adjusted to roughly 0.9-1.5 metres to match children's eye level, and high-saturation colours ($a > 20$, $b > 30$) were used to increase conspicuity in busy environments. Behaviour management symbols such as "No Touching", "Mind Your Head", or "No Climbing" were clustered around staircases, corners, and equipment zones (Fig. 2). These practices indicate a gradual shift from simple transplantation of adult-oriented signs towards a more systematic consideration of children's physical stature and perceptual thresholds, even though the overall visual language still reproduced adult safety norms.

From a broader perspective, these findings both confirm and nuance existing accounts of standardised wayfinding. V. Mehta & C. Auffrey (2022) argued that public signage in complex urban environments must

balance legibility with place-based identity, yet in the Safety-Dominant Phase legibility in the analysed cases was pursued almost exclusively through codified safety pictograms and high-contrast colour schemes, with little attention to local character. S. Jamshidi & D. Pati (2024) described contemporary public information symbols as negotiating between international standardisation and local adaptation; in the case corpus this negotiation appears only in embryonic form, as child-related signs are directly derived from adult-oriented ISO and GB systems with minimal semantic modification. At the same time, the emphasis on visual salience and redundancy resonates with cognitive studies showing that highly visible, iconic cues support children's comprehension of safety information (Motamedi *et al*., 2024; Bock *et al*., 2024; Wang *et al*., 2025).

a b c

Figure 1. Historical public information graphical symbols in China

Note: a – designed by Chen Hanmin (partial), later incorporated into China's national standard GB 3818-1983, b – Cover page of the draft GB 10001-1988 Graphical Symbols for Public Information Signs and selected adopted symbols, c – Newly added public information graphical symbols in GB 10001-1994 (partial)

Source: CSRES (n.d.a; n.d.b), WeChat Official Account (n.d.a)

a b

c

Figure 2. Child-oriented wayfinding design examples

Note: a – Suzhou Xinzhou Kindergarten (2005), b – Insect Carnival signage design at Beijing Happy Valley (2007), c – Children's Hospital affiliated with Zhejiang University School of Medicine (2006)

Source: WeChat Official Account (n.d.b), Mafengwo (n.d.), Zhejiang University School of Medicine Children's Hospital (n.d.)

Overall, the safety-dominant phase established a unified visual grammar for public information symbols and extended its influence into emerging child-oriented environments. In this period, children were primarily framed as vulnerable subjects requiring protection, and sign systems focused on making risk states and safety instructions highly visible. Although cultural and emotional considerations remained largely implicit, the

basic repertoire of pictograms, colour strategies, and ergonomic parameters for children's spaces was gradually consolidated. This phase therefore provided the material and regulatory infrastructure upon which later cultural-conscious and digital-intelligence developments could build. It also clarified the baseline from which the functional transformation of children's sign systems – from pure safety tools toward richer cultural and emotional mediators – would later unfold.

Cultural-Consciousness Phase. The cultural awakening of China's child-oriented sign systems represented a structural response to the long-term absence of cultural expression in earlier design practices. As N.V. Skliarenko *et al*. (2022) argued, visual communication design should be understood not only as a functional tool but also as a framework aligned with sustainable development and ecological strategies, which reinforces the necessity of embedding cultural and social values into child-oriented signage. Before the Cultural Industry Revitalisation Plan (General Office of the State Council of the People's Republic of China (2009), several factors constrained cultural consciousness in public spaces. Policy priorities centred on functional safety, as shown by the 1983 Public Information Graphical Symbols national standard, which unified signage but largely excluded cultural expression from institutional frameworks (Standardisation Administration of China, 1983). In parallel, the "quantity-over-quality" logic of rapid urbanisation (2000-2010) fostered reliance on universal design templates (Cheshmehzangi, 2018), exemplified by the 2005 signage for Suzhou Xinzhou Kindergarten, which prioritised generic safety symbols over regional cultural DNA. Technological and conceptual limitations further relegated cultural symbols to decorative roles, as in the 2007 Insect Carnival signage at Beijing Happy Valley, where visual playfulness diverged from deeper cultural connotation (Fig. 3).

a b c

Figure 3. Wayfinding system design for Ningbo Women and Children's Hospital

Note: a – Hospital Partial Decorative Wall (2014), b – Hospital Wayfinding Signage Design (2014), c – Hospital Corridor Visual Design (2014)

Source: Ningbo Women and Children's Hospital (2014)

From 2009 onwards, a cluster of national policies repositioned culture as a strategic resource and gradually normalised its integration into public space design. The 2009 Cultural Industry Revitalisation Plan designated cultural industries as a "national strategic sector" and called for the integration of cultural resources with modern production and technology (General Office of the State Council of the People's Republic of China, 2009). The 2011 Decision on Deepening Cultural System Reform and the 2015 Guidelines on Accelerating Modern Public Cultural Service Systems further linked cultural development targets to fiscal incentives, land use, and public service provision, emphasising both socialist core values and regional distinctiveness (The State Council of the People's Republic of China, 2011). Subsequent Five-Year Plans and the 2016 Opinions on Promoting Cultural Creative Product Development stressed the "living inheritance and modern reinterpretation" of cultural heritage and explicitly encouraged child-cognition-adapted cultural derivatives for museums, parks, and other public venues (General Office of the State Council of the People's Republic of China, 2016). These cultural-policy milestones, synthesised in Table 1, provided institutional incentives and resources for embedding local cultural motifs into children's sign systems rather than treating them as optional decoration.

Ningbo Women and Children's Hospital North Campus offers a representative example of this cultural turn. Its 2014 expansion into a "dual-campus synergy" model prompted Dalue Design Institute to reconceptualise wayfinding as cultural storytelling and emotional interaction (Ningbo Women and Children's Hospital, 2025). By deconstructing Ningbo's cultural genealogy, the designers extracted the local "Tangyuan" (glutinous rice ball) as a cultural genome and reconstructed it into a cognitively universal "Reunion Family" IP system. This translation of local cultural "genomes" into contemporary visual systems echoes recent work on integrating intangible cultural heritage elements into product and furniture design through symbolic semantics and multi-criteria evaluation (Chen *et al*., 2025). The design transposed Tangyuan's material "irregularity" and "adhesiveness" into embodied expressions within children's behavioural cognition models, aligning irregular forms with childhood individuality and interpersonal bonding. At the same time, the IP's dynamic combinatorial structure mirrored the functional complementarity and resource-sharing mechanisms between the hospital's northern and southern campuses, establishing a dual semiotic system of spatial narrative and institutional innovation (Fig. 3). At the material level, the case reconfigures sign carriers and spatial markers into soft, rounded, tactile forms; at

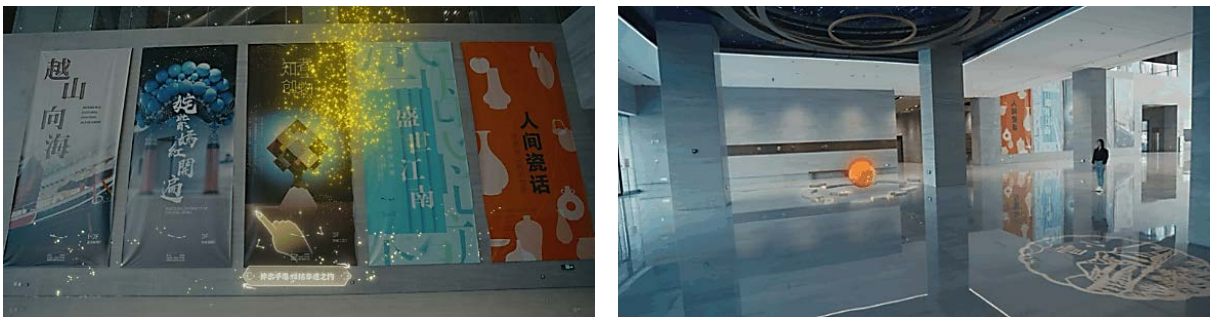
the institutional level, it encodes hospital management and service flows within a coherent visual identity; at the spiritual-emotional level, it constructs a reassuring image of reunion and care for children and their families.

From a broader perspective, the Cultural-Consciousness Phase aligns with research that frames signage as a vehicle for local identity rather than neutral infrastructure. M. Zeng (2015) showed that contemporary sign systems foreground regional motifs and narratives; the Tangyuan "Reunion Family" case concretises this shift by turning a local food symbol into a spatial IP that structures children's emotional experience. N.V. Skliarenko *et al*. (2022) argued that visual communication should be linked to sustainable and ecological strategies; in the study material this appears in the way recurring cultural genomes stabilise community meaning across institutional settings. G. Aiello (2020) highlighted how public visual communication participates in negotiations of visibility and belonging, a dynamic reflected in how hospital signage repositions children and caregivers from anonymous patients to members of a culturally defined "family". L. Chen *et al*. (2025) similarly emphasised the potential of intangible heritage motifs to mediate affect in everyday design.

Overall, the Cultural-Consciousness Phase marks a shift from purely safety-oriented graphics towards sign systems that actively embed regional culture and institutional narratives into children's environments. In this period, cultural symbols begin to move from superficial decoration to structured visual languages that support place identity and emotional reassurance. Children's sign systems increasingly serve as mediators between everyday space and local cultural memory, while still operating on the safety foundations established in the earlier phase. This lays the groundwork for later digital-intelligence developments, in which cultural semantics and emotional experience are further extended through interactive and intelligent media.

Digital-intelligence Innovation Phase in children's signage evolution. The digital-intelligent transformation of China's child-oriented sign systems is closely tied to recent national strategies for digital public services and child-friendly urban construction. The 14th Five-Year Plan (2021-2025) mandates the "equalisation of digital public services" and sets targets for building "digital twin communities" in most cities by 2025 (National People's Congress, 2021). Updated guidelines for child-friendly cities introduce "intelligent wayfinding systems" as mandatory indicators, calling for Augmented Reality/Mixed Reality (AR/MR)-based upgrades that enhance the emotional, interactive, and educational qualities of signage (China Association for Community Development, 2024). Under these frameworks, pioneering cities such as Beijing and Shanghai have invested in digital infrastructures that support dynamic updates and interactive experiences in child-oriented environments (Beijing Municipal Bureau of Economy and Information Technology, 2021; Shanghai Municipal People's Government Office, 2021). These policy and infrastructure developments, summarised in Table 1, provide the institutional and technical backdrop against which digital-intelligence innovations in children's sign systems have emerged.

Analysis of cases shows that digital technologies primarily operate as extensions of the material and cultural layers established in earlier phases. At the Zhejiang Intangible Cultural Heritage Museum, Rokid AR guidance technology uses point cloud scanning and six-degrees-of-freedom tracking to achieve centimetre-level positioning; children and caregivers wearing AR glasses can simultaneously perceive physical exhibits and virtual overlays, completing tasks that weave navigation with encounters with traditional craftsmanship (Fig. 4). This direction is consistent with findings that AR-based museum applications can enhance visitors' learning motivation and academic achievement, especially for younger audiences (Cheng *et al*., 2025). In the examined projects, digital devices – screens, sensors, AR terminals – do not replace static signage but cluster around key decision points and narrative nodes, creating "thickened" wayfinding zones where safety instructions, spatial cues, and cultural content are layered in time. In this configuration, Malinowski's material stratum is upgraded from fixed pictograms to adaptive interfaces, while the institutional stratum expands to include software rules, content management systems, and data protocols that govern how guidance information is generated and updated.



a b

Figure 4. AR experiences at Zhejiang Intangible Cultural Heritage Museum
Note: a – AR Experience View 1 (2025), b – AR Experience View 2 (2025)
Source: Zhejiang Intangible Cultural Heritage Museum (2025)

At the experiential level, the corpus reveals an increasing reliance on multimodal cues that align with children's cognitive and emotional characteristics. IoT sensors and edge-computing architectures enable the real-time capture of movement trajectories, dwell durations, and interaction patterns through touchscreens and audio-visual feedback (Open Systems Committee, 2012), while machine learning algorithms can dynamically adjust information hierarchies and delivery strategies based on spatiotemporal data (Cai *et al*., 2022). These technical capacities resonate with broader national agendas promoting cultural-technological integration (General Office of the State Council of the People's Republic of China, 2009) and can be repurposed from entertainment to cultural contexts: for example, targeting systems similar to those used in Shanghai Disneyland's "Buzz Lightyear Planet Rescue" can be adapted so that when children hit AR-projected traditional motif targets, they receive both navigational shortcuts and short narratives about local heritage. In parallel, multimodal interaction research indicates that integrating visual, auditory, and tactile channels can significantly enhance children's wayfinding efficiency when aligned with developmental characteristics (Petrini *et al*., 2016; Negen *et al*., 2019). Studies on audio-visual temporal integration (Qiu *et al*., 2025), visuo-haptic processing in children with atypical development (Purpura *et al*., 2024), multi-channel cognitive models (Ulusoy, 2023), and surveys of multimodal human-computer interaction (Tao *et al*., 2022) together provide system-level frameworks for designing cognitive-compliant interaction loops in complex public environments (Fig. 5). Considered alongside the case corpus, these findings suggest that child-oriented digital signage should be treated as a multisensory guidance ecology rather than a set of isolated screens.

a b c

Figure 5. Interactive scene from "Buzz Lightyear Planet Rescue" at Shanghai Disneyland
Note: a – Game Start Screen (2019), b – Game Score Interface (2019), c – Game Control Joystick (2019)
Source: Shanghai Disney Resort (n.d.)

Viewed against broader human-computer interaction and learning research, this phase refines rather than overturns existing accounts of AR-based and multimodal guidance. A. Cheng *et al*. (2025) showed that AR museum applications can enhance young visitors' motivation and learning; similarly, F. Xu *et al*. (2024) reported that AR-based egocentric visualisations improve indoor route learning and navigational efficiency. In the analysed cases, these effects appear within a layered semiotic structure where AR tasks interweave navigation with encounters with local craft. K. Petrini *et al*. (2016) and J. Negen *et al*. (2019) emphasised that combining visual, auditory, and tactile cues improves spatial performance when information is tuned to developmental constraints, a principle echoed in the multisensory zones around key decision points in the analysed cases. At the same time, multimodal interaction surveys by J. Tao *et al*. (2022) and N. Ulusoy (2023) underscored the need for system-level models, which is extended here by embedding such interfaces into embedding such interfaces into child-friendly city strategies and data-governance frameworks.

Overall, the Digital-Intelligence Innovation Phase marks a transition from static safety signage to responsive guidance ecologies that link physical space, data flows, and cultural narratives. In this period, children's sign systems become multi-layered interfaces that register movement and emotion while projecting culturally meaningful content. At the material level, sensors, displays, and AR devices reconfigure sign carriers into adaptive, multimodal surfaces; at the institutional level, data governance frameworks and smart-city platforms embed wayfinding into integrated service systems; at the spiritual-emotional level, participatory and playful interactions cultivate agency, curiosity, and reassurance for children and their caregivers. These shifts prepare the ground for an integrated evolutionary model in which digital intelligence extends, rather than replaces, the safety and cultural layers established in earlier phases.

CONCLUSIONS

China's child-oriented sign systems underwent a clear evolution from the 1980s onward, progressing from material provision to emotional empowerment within a semiotic framework. This study examined that trajectory and identified three developmental phases – Safety-Dominant, Cultural-Consciousness, and Digital-Intelligence Innovation – each associated with distinct transformations in the functions and meanings of signage. In the Safety-Dominant Phase (1983-2008), standardised visual grammars of high-contrast colours and geometric forms constituted the basic symbolic

repertoire for ensuring children's safety in public environments. In the Cultural-Consciousness Phase (2009-2018), signage was reinterpreted as a symbolic medium for identity construction, embedding regional motifs and cultural codes to support children's sense of belonging and reduce anxiety in sensitive spaces such as hospitals and kindergartens. In the Digital-Intelligence Innovation Phase (2019-present), semiotic principles were increasingly combined with intelligent technologies, and signs began to function as dynamic mediators that linked spatial guidance with children's cognitive characteristics and affective experiences. Taken together, these three phases demonstrated that semiotics operated not only as an analytical perspective but also as a design-oriented way of structuring decisions in child-oriented environments. By applying cultural stratification theory to children's wayfinding systems, the research articulated a stratified model that related material apparatus, institutional regulation, and spiritual-emotional meanings across historical stages. Rather than establishing a closed methodological system, the study proposed a structured analytical approach that connected cultural stratification theory with contemporary design strategies for child-friendly public spaces and helped clarify how safety, cultural identity, and emotional reassurance could be layered in practice.

Future research could build on these findings in several directions. First, empirical studies involving children, parents, and educators could systematically evaluate how different combinations of safety, cultural, and digital elements influence navigation behaviour, emotional responses, and symbolic learning in real environments. Second, comparative case studies across regions and countries could test the transferability of the three-phase, three-layer model and identify context-specific adaptations. Third, design-oriented research could translate the stratified model into practical tools such as evaluation checklists, co-design guidelines, or scenario-based prototypes – to support interdisciplinary collaboration among planners, designers, and policymakers. Finally, as digital-intelligent infrastructures continue to expand, further work is needed to address issues of data governance, accessibility, and inclusivity in children's sign systems, ensuring that technological innovation remains aligned with ethical, cultural, and developmental considerations.

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Еволюція засобів візуалізації знакових систем Китаю для дітей: семіотичний аспект

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Анотація. Актуальність цього дослідження полягає у вивченні того, як система самоорієнтування у громадських просторах, спрямована на дітей, перейшла від базових заходів безпеки до культурно та емоційно заряджених посередників на тлі змін стандартів, політики та цифрових технологій. Це дослідження мало на меті дослідити еволюцію інструментів візуалізації в китайських дитячих знакових системах з семіотичної точки зору. Спираючись на теорію культурної стратифікації Броніслава Маліновського, дослідження поєднало діахронічний аналіз національних та місцевих стандартів, політичних документів та репрезентативних випадків з дитячих лікарень, дитячих садків, тематичних парків та культурних закладів. Семіотично-стратифікаційний підхід було застосовано для інтерпретації змін на трьох рівнях: матеріальний апарат, інституційне регулювання та духовно-емоційні значення, підкреслюючи зв'язки між візуальними кодами та ширшими соціокультурними переходами. Результати дослідження визначили три історичні фази в еволюції китайських дитячих знакових систем: фаза домінування безпеки (1983-2008), що характеризується стандартизованими піктограмами, високо-контрастними кольорами та попереджувальною семантикою; фаза культурної свідомості (2009-2018), яка включала регіональні мотиви, символи місцевої їжі та елементи нематеріальної спадщини для реконструкції ідентичності та зменшення тривожності; та фаза інновацій цифрового інтелекту (2019-дотепер), яка інтегрувала доповнену реальність, Інтернет речей та інтерактивні інтерфейси для створення мультисенсорного, афективного досвіду керівництва та просторового управління на основі даних. У сукупності семіотично-стратифікаційний аналіз показав, що стандартизовані граматики безпеки, культурно вбудовані візуальні ідентичності та цифрово опосередковані мультисенсорні інтерфейси накопичувалися, а не просто замінювали один одного з часом, що виявляє коеволюцію дизайнерської практики з політичними програмами та соціальними очікуваннями. Результати пропонують концептуальні наслідки для ініціатив, орієнтованих на дітей, та для майбутнього дизайну орієнтирів, який враховує як технологічні інновації, так і безперервність місцевих культурних наративів

Ключові слова: дизайн системи самоорієнтування; середовище, орієнтоване на дітей; теорія культурної стратифікації; дизайн візуальної комунікації; емоційний досвід