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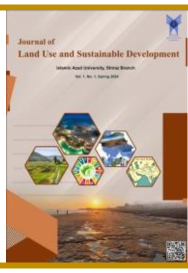

Original Research Page

Assessing the Quality of Spatial Organization and Wayfinding Perception in Transitional–Interface Spaces of Residential Complexes (A Case Study: of District 6 of Shiraz)

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Abstract

In recent years, the quality of transitional spaces in residential complexes has emerged as a crucial factor in helping residents find their way and improving their overall spatial experience. To fill a gap in existing research, this study investigated how these spaces influence wayfinding based on visual perception in District 6 of Shiraz. using a mixed-method approach, the research sought to answer two central questions: (1) Which visual perception components are key to wayfinding? and (2) How does the spatial layout of transitional areas affect wayfinding quality? In the qualitative phase, the research team identified core components through a detailed content analysis. For the quantitative phase, they surveyed 378 residents from nine selected complexes, using a questionnaire they had developed. the statistical analysis revealed that the average scores for environmental (2.65), human (2.72), and visual field (2.94) variables were all below optimal levels. The results also confirmed significant differences across various residential types, with lower scores found in complexes that had more blocks. Among the visual indicators, "environmental cues" (mean rank 3.76) and "spatial extent" (3.37) were the most influential, while factors like "enclosure" and "curvilinearity" had minimal impact. ultimately, a balanced combination of environmental factors (form, light, color, signage), human factors (accessibility, safety, social vitality), and visual factors (openness, field of view) is essential for improving legibility, safety, and ease of navigation. These findings offer practical guidance for designers to create residential interface zones that are more legible and easier to navigate.

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Introduction

In recent decades, with the accelerating growth of urbanization and increased density in Iranian urban residential areas, the quality of transitional interface spaces between private and public realms has gained increasing importance (Madani-Pour 2017; Keshavarz and Heydari 2019). Known as boundary-interface spaces, these areas serve as critical links between different spatial domains, playing a key role in promoting social interactions, enhancing lived experience, and improving the wayfinding process (Cao and Guo 2023; Mayer 2022). Despite their significance, the design quality of these spaces is often neglected in many contemporary residential complexes, particularly in high-density developments. This neglect leads to problems with environmental legibility, navigation, and the formation of residents' spatial sense of place (Gatel *et al.* 2008; Bentley *et al.* 1985).

Visual perception is considered a fundamental mechanism in the user's interaction with the physical environment, influenced by factors such as light, color, form, texture, signage, and spatial organization (Jamshidi *et al.* 2020; Montello 2014; Lee and Klippel 2016). These components affect how users form mental maps and make spatial decisions, ultimately determining wayfinding quality (Parto *et al.* 2021). However, a significant portion of prior research has largely studied each dimension—visual perception, spatial configuration, and wayfinding quality—in isolation. The simultaneous analysis of these factors within the interface spaces of residential complexes has received less attention (Ali-Niyay-Motalleb *et al.* 2020; Sassani *et al.* 2016).

Furthermore, methods like space syntax, which can analyze spatial configuration and produce metrics such as integration and choice (Hillier and Hanson, 1984), offer a prime opportunity to combine quantitative analysis of spatial structure with qualitative indicators of visual perception (Jamshidi *et al*. 2020). Despite this, the lack of integrated models that can simultaneously explain the effects of both spatial configuration and perceptual components on wayfinding quality for residents in residential complexes remains a research gap (Balilan Asl *et al.* 2015).

The city of Shiraz, as a major metropolis, faces additional challenges in designing these boundary-interface spaces due to its rapid urban growth, expansion of high-rise residential complexes, and changing settlement patterns. Construction policies in Shiraz have primarily focused on block placement and maximizing land use, giving less attention to the proper organization of residents' movement paths and the visual quality of transitional spaces. This issue is clearly evident in the residential complexes of Shiraz's District 6, where it manifests as reduced environmental legibility and difficulty in understanding routes for both residents and newcomers. Therefore, a scientific examination of this topic within the living context of Shiraz's District 6 can provide practical, replicable results for improving the design quality of residential complexes in other Iranian cities.

The innovation of this research lies in its presentation of a hybrid model that integrates the analysis of boundary-interface space configuration with visual perception components to enhance wayfinding quality in residential complexes. This model not only addresses the behavioral and cognitive aspects of users but also provides practical tools for designers working in contemporary Iranian architecture. Thus, this study aims to fill existing scientific gaps by explaining the role of boundary-interface spaces in wayfinding quality, based on visual perception components in the residential complexes of Shiraz's District 6. It seeks to answer the following questions:

1. What are the most important visual perception components that influence the wayfinding process in the interface spaces of residential complexes?
2. How can the configuration pattern of interface spaces improve users' wayfinding quality in a residential environment?

Literature Review

In recent years, the importance of transitional-interface spaces and their role in facilitating wayfinding within residential environments has drawn significant attention from architecture researchers. To begin, a considerable portion of studies has focused on the impact of spatial configuration and physical organization on residents' wayfinding quality. For instance, Ahmed *et al.* (2023) utilized Space Syntax analysis to demonstrate that the arrangement of residential blocks and the degree of spatial integration can have a direct effect on the ease of navigation. Building on this, Xu *et al.* (2023)

incorporated legibility indicators into this model, proving that combining spatial structure with the visual quality of paths and boundary spaces improves the user's wayfinding experience. Similarly, after studying multi-story urban complexes, Wang and Smith (2024) concluded that intermediate passages and boundary zones with appropriate visual openness can prevent user disorientation during the navigation process.

A different group of researchers has focused their work on the role of visual perception in guiding navigation within residential complexes. Kim and Kim (2020) by designing simulated environments and using eye-tracking technology, found that the presence of visual cues such as changes in materials, lighting, and form in the connecting areas of private and semi-private spaces strengthens the formation of users' mental maps. Similarly, Alinaghi and Giannopoulos (2024) by developing a step-by-step model, emphasized that visual obstructions and the sequence of environmental cues play a fundamental role in users' wayfinding decisions. In the same vein, Lee *et al*. (2022) showed that changes in lighting intensity and the creation of light contrast at spatial edges increase route predictability and improve spatial legibility in residential complexes.

Simultaneously, some studies have attempted to holistically investigate both spatial structure and visual perception components in boundary-interface spaces. By combining Space Syntax analysis with visual legibility assessment in dense urban residential complexes, Zhang *et al.* (2023) found that targeted signage at the boundary points between public and semi-private areas can significantly improve wayfinding quality. Focusing on residential complexes with Iranian-Chinese architectural styles, Huang *et al.* (2024) demonstrated that designing entrances and intermediate spaces with effective visual cues not only enhances the ease of navigation but also helps strengthen residents' sense of belonging. In a similar vein, Martinez and Roberts (2022) through field studies in European residential complexes, stated that the simultaneous use of diverse visual cues, changes in floor and wall materials, and the combination of directional colors in boundary spaces can meaningfully increase spatial legibility.

In domestic studies, Nasr *et al*. (2023, 2024) have focused on analyzing spatial organization and visual perception components in residential environments. They emphasized that spatial coherence and visual clarity in the connecting areas of spaces can play an effective role in enhancing the user's spatial experience and navigation (Nasr, Yarmoudi, and Moztarzadeh, 2023; Nasr, Kashmiri, Moztarzadeh, and Kakaei, 2024).

In summary, although a wide range of researchers have examined various structural and perceptual aspects of wayfinding, there is still no research that has been able to analyze and integrate spatial organization, visual perception quality, and the function of boundary-interface spaces in a holistic manner within a real-world context, particularly in Iranian residential complexes. In this regard, numerous researchers have addressed these topics, including Ahmed et al. on spatial structure, Xu et al. on route legibility, Kim and Kim on visual cues, Alinaghi and Giannopoulos on visual perception models, Lee et al. on route lighting, Zhang et al. on the combination of spatial configuration and visual signage, Huang et al. on the design of boundary entrances, and Martinez and Roberts on the analysis of materials and color in wayfinding, with each study pointing to specific components for improving wayfinding quality in residential spaces.

Explanation of Components and Variables for Wayfinding in Boundary-Interface Spaces Influenced by Visual Perception

In architectural and urban planning studies, analyzing how users interact with built environments holds a special place, with a large portion of this analysis based on theories of environmental cognition and environmental affordances. These theories enable a precise explanation of the components that influence wayfinding in boundary-interface spaces and help provide a deeper understanding of how the spatial and perceptual characteristics of an environment affect user behavior.

These theories include Space Syntax, Visual Perception, Gestalt, Environmental Stress, the Stimulus-Response model, Environmental Values, Place Attachment, and Ecological Perception. Each of these theories examines different dimensions of the human-space relationship. For instance, Space Syntax focuses on analyzing spatial structure and the distribution of spaces, while the theory of

Visual Perception addresses how users receive and process visual information.

Leveraging these theoretical foundations in design can lead to improved wayfinding quality and an enhanced spatial experience for users. Based on this, components such as visual cues, route legibility, spatial continuity, and environmental communications have been identified as the most important environmental affordances that play an effective role in facilitating movement and guiding users through interface spaces. A review of these related theories is presented in Table 1.

Table 1. Classification of Environment-Related Theories for Wayfinding in Boundary-Interface Spaces

Theory	Principles and Foundations	Main Components	Sub-Components	Application	Variables and Tests
Space Syntax	Analysis of axial maps, adjacency graphs, integration, connectivity, and coherence (Hillier and Hanson, 1984)	Axial maps, adjacency graphs	Integration, connectivity, coherence	Analyzing the role of boundary spaces in facilitating or restricting movement and wayfinding	Variables: Level of connectivity, integration; Tests: Agent and Isovist
Visual Perception Theory	Receiving visual information, transferring information to the brain, primary processing, interpretation, and analysis (Palmer, 1999)	Receiving visual information, transferring information to the brain	Primary processing, interpretation, and analysis	Improving user experience by using different colors, lighting, and materials in wayfinding spaces	Variables: Quality of lighting, use of colors
Gestalt Theory	Concepts of similarity, proximity, continuity, and closure (Koffka, 1935)	Similarity, proximity	Continuity, closure	Designing environments that facilitate users' understanding of spatial patterns and structures	Variables: Degree of similarity and proximity of patterns
Environmental Stress Theory	The impact of environmental factors such as noise, crowding, and lack of green space on human health and behavior (Lazarus, 1966)	Noise, crowding	Green space, air quality	Reducing stress and increasing user comfort by improving environmental factors	Variables: Level of noise, level of crowding, number of green spaces
Stimulus-Response Model	Human behavioral and emotional reactions to environmental stimuli (Watson, 1913)	Stimuli (light, sound, smell)	Behavioral responses, emotional responses	Improving the wayfinding experience by creating positive stimuli and reducing negative ones	Variables: Light intensity, sound level, type of smell
Theory of Environmental Values	The impact of personal and cultural values on the perception of and interaction with the environment (Rapoport, 1996)	Personal values, attitudes	Culture, past experiences	Designing environments that are compatible with users' values and needs	Variables: Type of personal values, attitudes, cultural influences
Place Attachment Theory	Emotional and psychological connections of individuals to specific places (Rapoport, 1996)	Emotional connections, meanings of place	Individual experiences, memories	Improving the ability to wayfind and navigate by creating a sense of belonging to a place	Variables: Degree of attachment, emotional meanings of a place
Ecological Perception Theory	Direct perception of the interactions between an individual and the environment without the need for complex cognitive processing (Gibson, 1979)	Physical features of the environment, individual's interaction with the environment	Perception of environmental texture, perception of scale	Designing spaces that provide users with natural and understandable information for wayfinding	Variables: Textural differences, light and shadow patterns, changes in ground elevation

Source: Authors' library studies, 2025

Based on the theories discussed, wayfinding in the boundary-interface spaces of residential complexes is understood as a multi-dimensional process resulting from the interaction among three groups of variables: environmental components, visual perception, and users' spatial cognition. Initially, the physical structure of spaces and the relationships between their components provide features such as integration and visual coherence (Dong & van Ameijde 2023; Khozaei Ravari et al. 2022). Users then mentally process this structure and imbue it with their personal experience and knowledge (Wu et al. 2025; Henderson & Kubovy 2022).

In this process, boundary-interface spaces act as connection points between different realms and, with visual cues like color, light, form, and social vitality, play a key guiding role in route selection (Qiu et al. 2023; Zhang & Huang 2023; Feng & Duives 2023). Furthermore, characteristics of the visual field, such as isovist, visual closure, and visual convexity, have a direct impact on the clarity and ease of navigation (Turner 2023; Stamps 2024). Environmental, human, and visual variables work together within an integrated conceptual framework and constitute wayfinding in this study. Figure 1 illustrates the parameters influencing wayfinding and served as the basis for the questionnaire's design (Fig. 1).

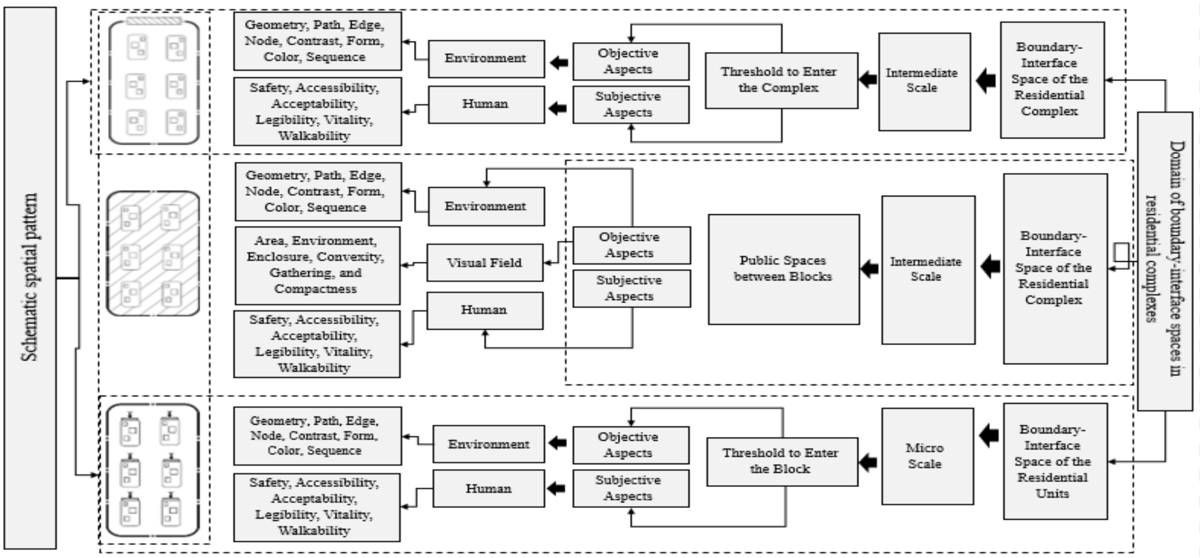


Fig1. Integrated Model of Components Influencing Wayfinding in Boundary-Interface Spaces
Source: Compiled by the researcher using studies from Ahmed et al. (2023), Kim and Kim (2020), Xu et al. (2023), Alinaghi and Giannopoulos (2024), Zhang et al. (2023), Huang et al. (2024), and other relevant theoretical sources

The Area under Study

The spatial domain of the study was the residential complexes in District 6 of Shiraz, an area characterized by significant physical, environmental, and social diversity. Due to its rapid growth of residential complexes and the formation of diverse boundary-interface spaces, this district provided a suitable context for the research's focused analysis.To identify appropriate case studies, all residential complexes within District 6 were first identified using municipal data and the master plan. An initial evaluation was then performed using a standard observational checklist based on three main components: environmental, human, and visual. Only complexes that scored an average above 3 on a 5-point scale for all three dimensions were selected for analysis.

To account for physical diversity and different scales, the residential complexes were categorized into three groups based on the number of building blocks:

- Group 1: Complexes with 2 to 4 blocks
- Group 2: Complexes with 5 to 10 blocks
- Group 3: Complexes with more than 10 blocks

From each category, the three complexes with the highest quality scores were selected, for a total of nine case studies. These nine samples were then used for the field questionnaire and statistical analyses during the quantitative phase of the research. This sample diversity allows for the generalizability of the findings to a variety of residential complex types (Fig. 2).

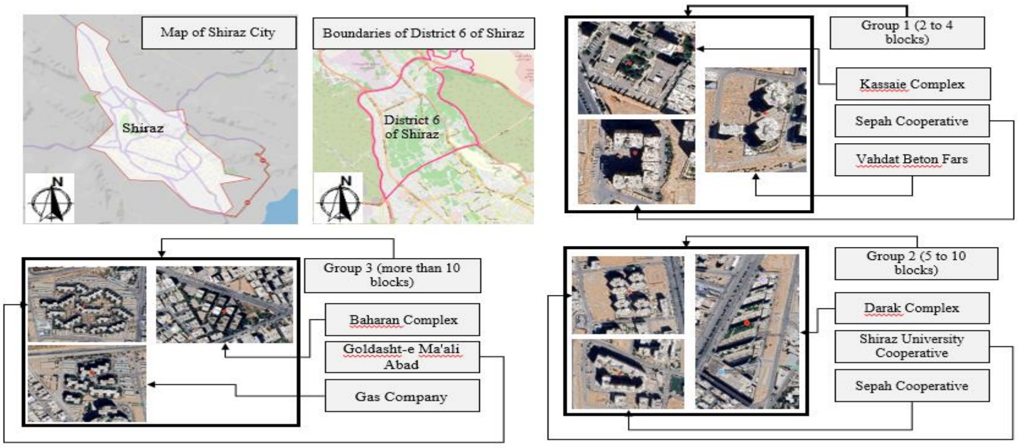


Fig 2. Study areas in District 6 of Shiraz metropolis

Methodology

This research is applied in its objective and employs a mixed-methods approach in its methodology, leveraging both qualitative and quantitative data. This mixed approach allowed for a deeper analysis of the subject's various dimensions and enabled the extraction of measurable, scientific components.

In the first stage, the qualitative phase of the research was conducted using a systematic content analysis of theoretical sources. To this end, after a comprehensive review of relevant domestic and international literature on boundary-interface spaces, visual perception, and wayfinding quality, the study's main components were extracted across three dimensions: environmental, human, and visual (field of view). The academic sources used in this stage included classic theories and recent integrated models, with key measurable components for the quantitative phase being defined through inductive reasoning.

In the quantitative phase, field data were collected using a researcher-developed questionnaire to measure the impact of the components extracted in the qualitative phase. The questionnaire was designed based on the three dimensions: Environmental (e.g., light, color, form, signs), Human (e.g., security, accessibility, legibility, and vitality), and Visual (field of view, including visual area, enclosure, convexity, etc.). A five-point Likert scale was used for scoring the questions. To ensure the validity of the data collection tool, the questionnaire's validity was confirmed by experts and specialists in architecture and urban design. Its reliability was also established using Cronbach's alpha test ($\alpha>0.80$). The data collected were analyzed using SPSS and AMOS software. The statistical tests used in this section included:

- Kolmogorov–Smirnov test: To check for the normal distribution of the data.
- One-sample t-test: To assess the significance of the components' mean relative to the benchmark value (3 on the Likert scale).
- One-way Analysis of Variance (ANOVA): To compare the difference in the mean of variables across different groups of residential complexes.
- Friedman test: For ranking and prioritizing the three components (environmental, human, and visual) from the perspective of wayfinding quality.

The statistical population for this study comprised all residents of the selected residential complexes in District 6 of Shiraz, who were chosen as case studies based on an observational checklist. Given the nature of the research and the necessity of collecting field data on residents' lived experiences, the unit of analysis was the households residing in the selected complexes. According to official statistics from District 6 Municipality of Shiraz and estimations based on the number of blocks, residential units, and household population rates, the population of the nine selected complexes was estimated to be over 28,000 people. To determine the sample size with a 95% confidence level and a 5% margin of error, Cochran's formula for finite populations was used, which calculated the required sample size to be 378 people. The samples were distributed proportionally across the three groups of selected complexes, with 126 questionnaires being randomly distributed among residents of each group for data collection.

Results and discussion

Data Normality Assessment

The Kolmogorov–Smirnov test was performed to assess the normality of the variables' distribution. The results (Table 2) showed that the significance level (Sig.) for all variables was greater than 0.05, indicating that the data are normally distributed. This confirmed that parametric tests could be used for the subsequent analysis.

Table 2. Results of the Kolmogorov–Smirnov Test for Data Normality

Variable	K-S Test Statistic	Significance Level (Sig.)
Environmental	0.19	0.09
Human	0.26	0.17
Visual Field	0.31	0.20

Evaluation of Variable Desirability

To measure the overall desirability of the Environmental, Human, and Visual Field variables, a one-sample T-test was conducted against a baseline value of 3. The results (Table 3) showed that the mean scores for the environmental (2.65) and human (2.72) variables were significantly lower than the average desirability level ($p<0.05$). In contrast, the visual field's mean score (2.94) did not significantly differ from the value of 3 ($p>0.05$). These findings suggest that the environmental and human quality is undesirable, while the visual field is at an average level.

Table 3. Results of the One-Sample T-Test for Evaluating Variable Desirability

Variable	Mean	Standard Deviation	T-value	Significance Level (Sig.)
Environmental	2.65	0.42	-7.87	0.0001
Human	2.72	0.58	-4.51	0.0001
Visual Field	2.94	0.37	-1.35	0.18

Comparison of Variable Means Across Three Groups

An ANOVA test was performed to compare the mean scores of the environmental, human, and visual field variables across the three residential complex groups. The results (Table 4) indicated a statistically significant difference in the mean for all three variables between the groups ($p<0.05$). Group 1 had the highest mean score and Group 3 had the lowest, demonstrating that the quality of these indicators decreases as the number of blocks increases.

Table 4. Results of the ANOVA Test for Comparing Variable Means Across Three Residential Complex Groups

Variable	Group 1	Group 2	Group 3	F-value	Significance Level (Sig.)
Environmental	3.05	2.65	2.23	75.96	0.0001
Human	3.42	2.56	2.17	178.28	0.0001
Visual Field	3.11	3.00	2.72	10.10	0.0001

Pairwise Comparison of Groups (Tukey's Test)

To precisely identify the differences between the groups, a Tukey's multiple comparison test was conducted. The results (Table 5) showed that the Environmental and Human variables had significant differences between the groups. However, the difference in the mean of the visual field variable was not significant across the groups, and its values were relatively close.

Table 5. Results of the Tukey Test for Pairwise Comparison of Residential Complex Groups

Variable	Group 1	Group 2	Group 3	Significance Level (Sig.)
Environmental	3.05	2.65	2.23	1
Human	3.42	2.56	2.17	1
Visual Field	3.11	3.00	2.72	0.45

Ranking of Visual Field Components with Friedman's Test

A Friedman test was performed to rank the components of the visual field, including area, perimeter, enclosure, convexity, and closeness. The results (Table 6) revealed a significant difference among the components ($p<0.05$). Perimeter and area had the most significant impact, while enclosure and convexity showed the least impact.

Table 6. Results of the Friedman Test for Ranking Visual Field Components

Component	Mean Rank
Perimeter	3.76
Area	3.37
Closeness and Compactness	2.70
Convexity	2.59
Enclosure	2.58

The quantitative and qualitative analyses revealed that the quality of wayfinding in residential complexes is influenced by three main groups of components: environmental, human, and visual. Environmental components such as form, lighting, and color were effective in improving spatial cohesion and the legibility of paths. However, in complexes with a higher number of blocks, a decline in environmental quality was evident due to increased density and limited open spaces. The findings also indicated that human components like security, accessibility, and social vitality are highly important for enhancing wayfinding quality, and these components were in a more favorable state in smaller complexes. Among the visual components, the physical dimensions of the visual field (perimeter and area) had the most significant impact on the perception of paths, while closure and convexity showed a lesser effect.

An examination of the relationship between these components showed that desirable wayfinding quality is achieved when a harmonious balance and interaction is established between environmental factors (e.g., form, light, and color), human factors (e.g., security, accessibility, and vitality), and visual factors (including legibility, visual field, and spatial openness). A weakness or strength in any one of these components can affect the other dimensions. This balanced structure is conceptually shown in Figure 3, which illustrates the synergy and internal connection of these three components in shaping the spatial experience and enhancing wayfinding quality (Fig. 3).

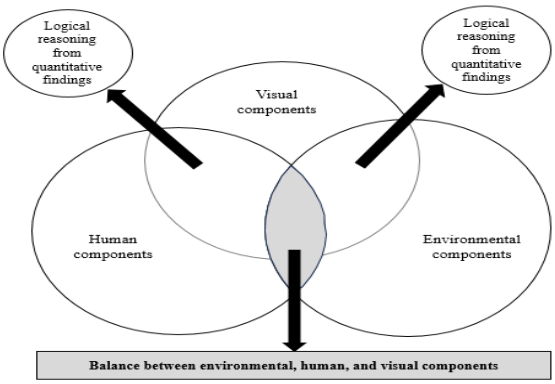
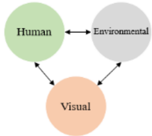
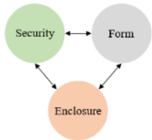
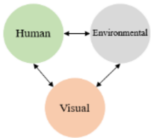
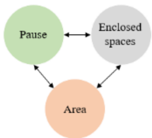
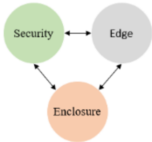
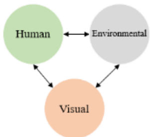
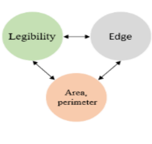


Fig 3. Conceptual Model of the Balance between Environmental, Human, and Visual Components

To supplement the study's statistical analysis and gain a more precise understanding of how the environmental, human, and visual components interact to shape wayfinding quality, the questionnaire findings were qualitatively analyzed. This analysis showed that the interrelationships among indicators such as accessibility, spatial form, lighting, color, spatial dimensions, and spatial sequence play a decisive role in improving users' perception of paths and movement experience. These findings confirm that coherence among physical, perceptual, and behavioral factors can lead to increased legibility, security, and vitality in the movement paths of residential complexes. These relationships between the influential variables and components are briefly presented in Table 7.

Table 7. How Variables Influence Each Other Based on Statistical Questionnaires

Description	Relationship between Components	Relationship between Variables
The main entrance of a residential complex has a direct relationship with the accessibility of the path and the expansion and area of the entrance environment.		
Access from the main entrance to a specific block is related to the pedestrian-friendly nature and the user's clear perception in path selection, as well as spaces with a high environmental hierarchy. The questionnaire analysis focused on the relationship among these three aspects.		
The building form (environmental) had a direct relationship with creating a sense of enclosure and compactness but did not establish a distinct relationship with human variables, except in parts of residential complexes where poor night lighting around these forms conveyed a sense of insecurity to residents.		
Night lighting is effective for residents to monitor the entry and exit of strangers.		
The color of the blocks (environmental), curbs, and green spaces—which create higher vitality (human)—play a major role in residents' path selection.		
Creating appropriately sized open areas for gathering between blocks and enhancing social relationships among neighbors, where they can pause along their path, along with the furniture and enclosed spaces for children's play (visual), can influence residents' path choices.		
Providing appropriate lighting for green spaces and play areas with suitable spatial dimensions creates a feeling of security for parents and facilitates greater supervision.		
Color contrast, such as in the paving of a walkway, helps users in determining their direction.		
Creating a protective edge and walls around complexes helps to heighten residents' sense of security and define the supervised area.		
The presence of a planted edge is effective both for orientation and for the legibility of movement paths, defining the perimeter and area of each section.		
Spatial sequence from the main entrance to each building block is important for reaching a destination and for legibility in path selection.		

Analysis of the Energetic Relationship Between Components in Wayfinding

Based on the results of the analyses, Figure 4 illustrates a conceptual model of the energetic relationship among the environmental, human, and visual components in shaping wayfinding quality. In this model, environmental components including form, signs, path, edge, node, color, contrast, light, and spatial sequence facilitate users' spatial guidance by enhancing the legibility and clarity of routes. Human components, such as accessibility, security, control, supervision, pedestrian-friendliness, legibility, and social vitality, directly interact with the environmental components to improve the quality of the movement experience. Additionally, visual components like area, perimeter, enclosure, convexity, and compactness play a decisive role in the perception of paths and in reducing user confusion by adjusting the field of view and spatial coherence. This model shows that wayfinding quality depends not only on environmental factors (like form and light) but also on human components (like security and legibility) and visual components (like field of view and compactness). Therefore, integrated design, proper interaction between components, and the reinforcement of key wayfinding factors play a decisive role in the ease of movement, security, and user experience. Within this structure, the boundary-interface space acts as a point of interaction and synergy, where the harmony between components leads to increased wayfinding quality and user satisfaction(Fig. 4).

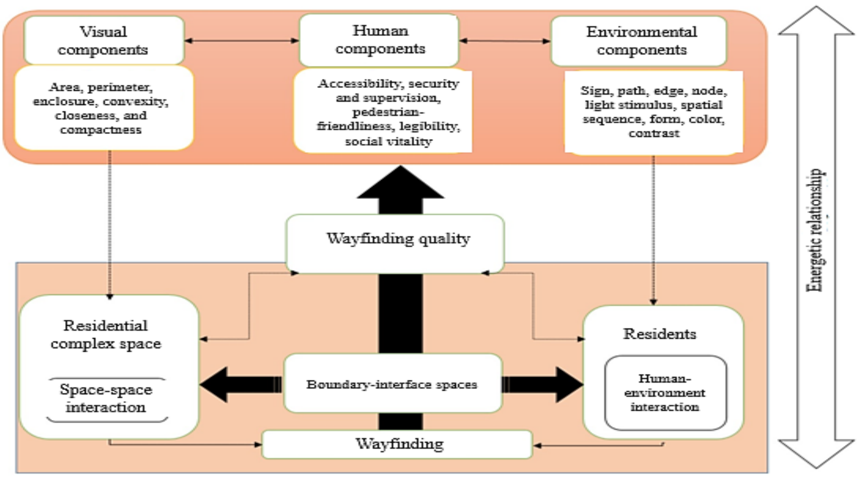


Fig 4. Energetic Relationship Between Components

Conclusion

The present study aimed to explain the role of boundary-interface spaces in enhancing wayfinding quality for residents of residential complexes in District 6 of Shiraz. This was based on a combined analysis of visual perception and spatial configuration components.

The research sought to answer two main questions: first, to identify the most important visual perception components influencing the wayfinding process in boundary-interface spaces, and second, to analyze how the spatial organization pattern affects the improvement of users' movement experience.

To this end, an integrated approach based on qualitative and quantitative methods was used, which on one hand enabled the analysis of the environment's spatial structure, and on the other, considered users' subjective evaluations through perceptual indicators.

The results from this multi-layered approach showed that three main components—environmental (form, light, color, signs), human (accessibility, security, social vitality), and visual (field of view, spatial openness, compactness)—in interaction with each other, determine the wayfinding quality in residential environments.

The research findings indicate that the coherence and balance among these three component groups lead to increased spatial legibility, reduced confusion in movement, and a strengthened sense of security and belonging among residents. In this context, the boundary-interface space acts as a focal point for the interaction of these components and plays a key role in guiding users.

Based on the conceptual models derived, the optimal design of these spaces can improve the wayfinding process and help enhance the lived experience in residential complexes by using a suitable spatial sequence, purposeful lighting, visual signage, and the definition of clear boundaries.

Therefore, the results of this research can be used as a basis for developing design strategies in dense urban residential contexts and can partially fill the gap in combined physical-perceptual approaches in architectural design.

References

Ahmed, S., Zhao, Y., & Li, F. (2023). Spatial configuration and navigability in high-density residential blocks: A space syntax approach. *Journal of Urban Design, 28*(2), 145–167.

Alinaghi, S., & Giannopoulos, I. (2024). Sequential visual cues and cognitive mapping in residential navigation: Extending Downs and Stea model. *Cognitive Processing, 25*(1), 55–70.

Ali Niyay Motalleb, A., Shakouri, R., & Eyneifar, A. (2020). Elucidating the concept of liminality in the interaction between inside and outside boundaries in architecture. *Journal of Fine Arts: Architecture and Urbanism, 25*(2), 31–42. https://doi.org/10.22059/jfaup.2020.304505.672477 [In Persian]

Balilan Asl, L., & Sattarzadeh, D. (2015). The role of in between (interstitial) space in the spatial organization of architectural and urban elements in Iran: Case study of Tabriz city during the Qajar period. *Journal of Environmental Science and Technology, 17*(2), 169–181. [In Persian]

Dong, H., & van Ameijde, J. (2023). Spatial integration and visibility coherence in residential wayfinding: A configurational perspective. *Journal of Architectural and Planning Research, 40*(1), 55–72.

Feng, T., & Duives, D. (2023). Visual connectivity and pedestrian route choice in mixed-use developments. *Journal of Transport Geography, 105*, 103516.

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Henderson, D., & Kubovy, M. (2022). Mental processing of complex spatial layouts: Human strategies in urban navigation. *Cognitive Research: Principles and Implications, 7*(1), 15–32.

Hillier, B., & Hanson, J. (1984). *The social logic of space*. Cambridge: Cambridge University Press.

Huang, L., Zhang, T., & Wang, S. (2024). Cultural hybrid entrances and boundary spaces: Visual design strategies for Iranian-Chinese residential complexes. *Journal of Housing and the Built Environment, 39*(1), 77–99.

Javanmardi, M., Nasr, T., & Mahdinejad, J. (2023). Formulation of principles for enhancing the quality of private residential space with a visual perception approach based on visual ecology (Video Ecology). *Haft Hesār Journal of Environmental Studies, 11*(46), 5–22. [In Persian]

Khozaei Ravari, M., Gharipour, M., & Tavakkoli, M. (2022). Morphological patterns and spatial legibility in Iranian residential complexes. *Urban Design International, 27*(2), 125–142.

Kim, S., & Kim, H. (2020). Visual landmarks and eye-tracking analysis in residential wayfinding: Experimental studies in simulated environments. *Journal of Architectural and Planning Research, 37*(4), 311–328.

Koffka, K. (1935). *Principles of Gestalt psychology*. New York: Harcourt, Brace & World.

Lazarus, R. S. (1966). *Psychological stress and the coping process*. New York: McGraw-Hill.

Lee, J., Park, M., & Choi, S. (2022). Lighting contrast and spatial predictability: Enhancing wayfinding clarity in housing complexes. *Lighting Research & Technology, 54*(7), 915–932.

Low, S. M. (1992). Symbolic ties that bind: Place attachment in the plaza. In I. Altman & S. M. Low (Eds.), *Place attachment* (pp. 165–186). New York: Plenum Press.

Martinez, A., & Roberts, P. (2022). Surface materials, color guidance, and spatial legibility in European housing transitions. *Journal of Urban Design and Development, 28*(3), 243–265.

Nasr, T., Kashmiri, H., Moztarzadeh, H., & Kakaei, F. (2024). Investigation of the spatial organization performance of single-sided Pahlavi I houses in Shiraz (Case study: Zakeri House). *Journal of Design and Planning in Architecture and Urbanism, 2*(2), 12–24. [In Persian]

Palmer, S. E. (1999). *Vision science: Photons to phenomenology*. Cambridge, MA: MIT Press.

Parto, Sh., Amirkhani, A. A., & Rahnama, M. R. (2021). Exploring the role of walls in the dialectic of disjunction and conjunction. *Bagh-e Nazar, Scientific Journal of Art, Architecture & Urbanism, 18*(97), 17–30. [In Persian]

Qiu, L., Zhou, J., & Sun, K. (2023). Visual cues and boundary markers in transitional spaces: Their role in urban pedestrian wayfinding. *Journal of Urban Design, 28*(4), 512–530.

Rapoport, A. (1996). *The meaning of the built environment: A nonverbal communication approach* (Rev. ed.). Tucson: University of Arizona Press.

Sassani, M., Eyneifar, A., & Zabihi, H. (2016). Analyzing the relationship between interstitial space quality and human environmental qualities (Case study: Residential complexes in Shiraz city). *Journal of Fine Arts: Architecture and Urbanism, 21*(2), 69–80. [In Persian]

Stamps, A. E. (2024). Visual closure, convexity, and perceived navigability in architectural spaces. *Perceptual and Motor Skills, 131*(2), 487–506.

Turner, A. (2023). Isovist analysis in complex architectural layouts: Visibility fields and movement behavior. *Environment and Planning B: Urban Analytics and City Science, 50*(7), 1302–1321.

Wang, L., & Smith, D. (2024). The role of transitional visual openness in wayfinding within multi-storey residential complexes. *Journal of Environmental Psychology, 92*, 102000.

Watson, J. B. (1913). Psychology as the behaviorist views it. *Psychological Review, 20*(2), 158–177.

Wu, X., Lin, J., & Chen, Z. (2025). Cognitive representation of spatial sequences in residential navigation: The role of prior experience and spatial knowledge. *Journal of Environmental Psychology, 93*, 102035.

Xu, J., Chen, H., & Lin, P. (2023). Visual legibility and wayfinding: Integrating spatial layout with visual cues in residential environments. *Environment and Planning B: Urban Analytics and City Science, 50*(3), 456–478.

Zhang, Y., & Huang, L. (2023). Visual permeability and boundary articulation in complex residential neighborhoods. *Journal of Housing and the Built Environment, 38*(2), 203–222.

Zhang, Y., Liu, W., & Chen, X. (2023). Combined analysis of space syntax and visual legibility for residential wayfinding improvement. *Journal of Urban Planning and Development, 149*(4),* 04023041.