

Reading of Wayfinding and Factors Affecting Visual Perception in In-between Spaces in the Residential Environment in the Pre-operation Stage; Case Study: Kerman*

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ABSTRACT

Despite the influence of the legibility of the space and the facilitation of navigation in in-between spaces in residential complexes on the quality of residents' social lives, common residential construction policies in Kerman and other cities of Iran, emphasize the layout of blocks in residential complexes, leading to the inattention to the spatial quality of the passageways used by residents in the post-operation phase. Therefore, considering the psychological aspects, the present study aims to find the spatial elements and features facilitating the wayfinding process in in-between spaces in residential complexes. The main question is: How can the factors affecting wayfinding in in-between spaces in residential complexes be increased in the pre-operation phase when the designer does not have access to the residents? In this research, residents' visual perception is assessed in the pre-operation stage by cross-checking residents' visual perception in three case studies and assessing visual factors in in-between spaces with the help of Depthmap software. The required data are collected using a questionnaire and, then, analyzed in SPSS software. The sample size is 90 persons. The results indicate that environmental, human, and visual components include landmarks, edges, paths, colors, light, walkability, social vitality, etc., each of which is effective in wayfinding at various levels of the in-between space and can enhance factors affecting wayfinding in in-between spaces in the pre-operation phase when the designer does not have access to the residents.

Keywords: Wayfinding, Visual Perception, Residential Complexes, Pre-operation, In-between Space.

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1. INTRODUCTION

The development of societies has caused designers to pay more attention to the quality of spaces and extensive research has been carried out on the quality of space on human perception (Tavassoli 1997, 68). In the present study, in-between spaces in residential complexes are studied.

The legibility of space and wayfinding are of great importance. Wayfinding takes place through legible space, separation, and emphasis on realms, and spatial circulation. Wayfinding in in-between spaces

in residential complexes, as spaces connecting the inside and outside of the houses, influences the mental and environmental qualities of the residents (Khajeh et al. 2012).

The present research aims to investigate residents' wayfinding in in-between spaces in residential complexes to show to what extent the quality of construction and design can be enhanced in the post-operation stage by examining the variables in the pre-operation phase (Fig. 1).

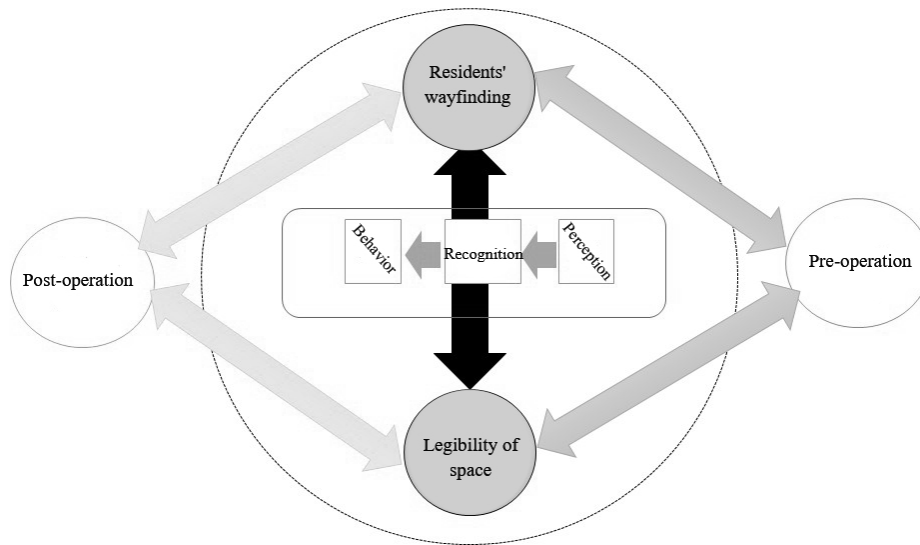


Fig. 1. The Model of the Relationship between Pre- and Post-operation Stages in the In-between Spaces in Residential Complexes

1.1. The Importance and Necessity of Research

Inadequate attention to in-between spaces in existing housing construction policies, the problem of wayfinding in in-between spaces in the post-operation phase, inattention to visual perception in in-between space patterns, and the illegibility of these spaces, and confusion of residents or users have prompted authors to investigate the role of the capabilities of in-between space in residential complexes at various levels (from macro to meso) in improving the quality of wayfinding.

1.2. Research Innovative

There are few studies that have addressed visual perception in the post-operation stage, leading to the lack of information for the analysis of cases related to in-between spaces from the perspective of visual perception.

One of the innovations of the present study is the provision of solutions to improve the quality of wayfinding in in-between spaces in residential environments in the pre-operation phase to improve the design by cross-checking numerous components in the post-operation.

1.3. Research Objectives

The objectives of the present study are as follows:

- To provide solutions to improve the quality of wayfinding in the post-operation phase, considering the wayfinding process based on the residents' visual perception;
- To obtain a tool to assess the quality of wayfinding in the in-between space in residential environments in the post-operation stage to cross-check the components and how they interact.

1.4. Research Question

How can the factors affecting wayfinding in in-between spaces in residential complexes be increased in the pre-operation phase when the designer does not have access to the residents?

1.5. Research Hypothesis

As the quality of the in-between space design is enhanced through the designers' attention to the subject expectations extracted from the residents' visual perception in the pre-operation stage, the quality of these spaces increases in the post-operation stage.

2. THEORETICAL FOUNDATIONS

The history of wayfinding in in-between spaces is closely related to issues addressed in environmental psychology, although there are few studies in this regard.

After the failure of residential projects in the 1950s and 1960s, topics such as "post-occupancy evaluation" were raised. Cooper Marcus has performed some studies on how housing is connected to the surrounding environment and raised issues such as behavioral settings, etc. (Hua 1981).

The following includes the descriptions of the keywords. In the present research, the words in-between space, wayfinding, and visual perception and the relevant theories used to extract research variables and components are described and discussed. The components are divided into three environmental, semantic, and visual areas. Figure 2 shows the relationship between wayfinding and research variables in the structure of the in-between space in residential complexes.

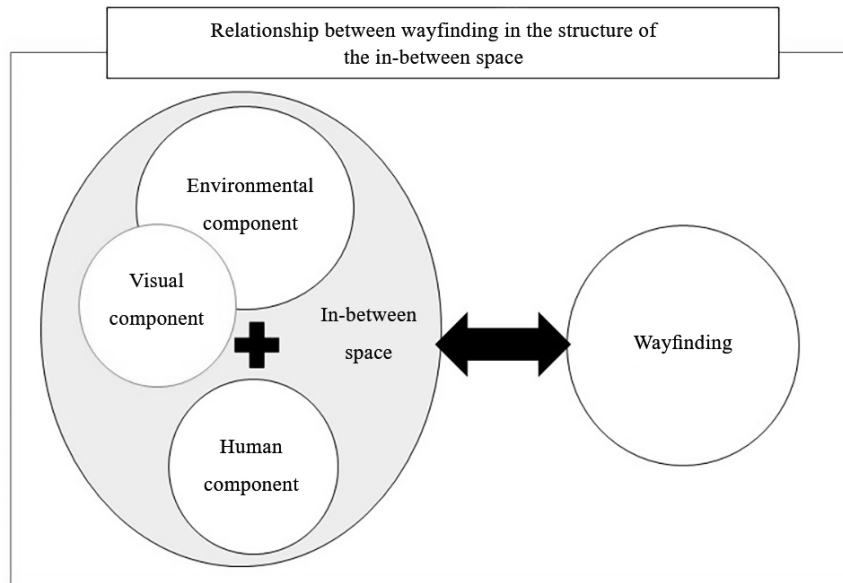


Fig. 2. Physical, Semantic, and Visual Wayfinding Model

2.1. Applied Research Words

In the present study, the keywords of in-between space (space between inside and out), wayfinding, and visual perception have been investigated to follow the historical trajectories of the words.

2.1.1. Space between Inside and Out

Various definitions have been presented for the space between inside and out, i.e. a space that is neither internal nor external, and basically has the role of connecting these two areas. Researchers such as Skjaeveland and Garling (1997), Anderson (1991), Hillier and Hanson (1984), Hajer and Reijndrop (2001), Stevens (2007) have presented various views on the relationship between the inside and outside and the space connecting the two. They have used terms such as threshold space, middle space, soft edge, retaining space, boundaries between public and private spaces, threshold, and intermediate zone in this regard (Sasani et al. 2016).

2.1.2. Wayfinding

Regarding wayfinding, the following classification can be presented:

The first group includes the research by Kevin Lynch in 1960, who addressed issues related to wayfinding in street using landmarks for the first time. He has introduced 5 components of landmarks, paths, districts, nodes, and edges according to people's spatial knowledge of urban environments, which have been considered spatial navigation by some researchers (Arthur and Passini 1992; Lynch 1960). Generally, his findings are described as "wayfinding with an architectural approach" (Rooke et al. 2009). The second group includes the findings obtained by researchers such as Kaplan and Downs (Stea) who have analyzed the issue of wayfinding in the field of cognitive studies and their findings have led to studies in the field of decision-making with audiences (Downs and Stea 1973; Kaplan and Kaplan 1982; Rooke et al. 2009). The third group includes the recent research by Passini, who has integrated wayfinding with architecture and the results of his research have been used to solve place-related issues. He and Arthur have published an environmental resource in the field of knowledge of wayfinding related to design language (Arthur and Passini 1992; Passini 1984; Rooke et al. 2009). Downs and Stea (1977) have formed a new perspective

on the wayfinding process and cognitive mapping to consider perception and cognition in targeted wayfinding. Besides Downs and Stea, Kaplan (1976) and Passini (1977) have also presented their new perspectives.

In the present study, the views of various theorists in the field of visual perspectives and environmental behavior have been examined. They have often analyzed concepts related to spatial legibility and wayfinding (Khame et al. 2016).

The wayfinding process includes three mental operations: information processing, decision-making, and decision execution (Abu-Ghazzeh 1996).

2.1.3. Visual Perception

Eyesight, as the most important sense in visual perception, allows for obtaining new experiences. This perception has a direct relationship with humans and their behaviors. nowadays, visual disturbance

and abnormality influence the human environment more than ever due to the ignorance of some of the consequences of visual perception (Pourjafar and Alavi Belma'ani 2012). Researchers consider visual perception obtained by senses and the processing of information received from the surroundings (Naghizadeh 2007).

Figure 3 shows the relationship between wayfinding and the process of spatial perception, spatial cognition, and spatial behavior. These are divided into environmental, human (semantic), and visual components and the corresponding variables are extracted using the theories presented in the next section. In the present study, how a person does wayfinding through his perception and attention to the environment was examined in three reality, subjectivity, and objectivity categories. This research has investigated this in in-between spaces in residential complexes.

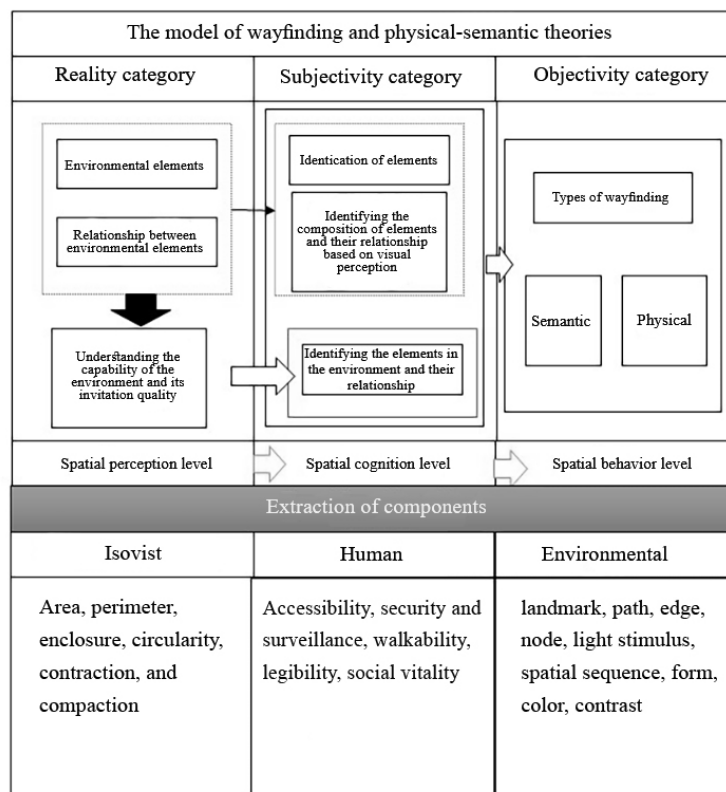


Fig. 3. The Relationship between Wayfinding and Components Involved in the Wayfinding Process

2.2. Theories used in the Design of the Effective Wayfinding Model

In this section, the theories with an essential role in extracting the research components are presented. These theories are often based on the knowledge of environmental psychology and address perception and behavior resulting from the cognition of the environment.

2.2.1. Gibson's Theory of Affordances

The theory of affordances (Gibson 1979) is based on environmental psychology. According to Gibson, this perceptual flow is formed by constants extracted from a stimulating process. he has called these constants abilities. Based on Gibson's theory, the user and his environment cannot be separated from each other, and he has called this complementary principle ecological physics.

2.2.2. Gibson's Theory of Invitation Quality

Gibson quotes the concept of invitation from Kurt Lewin. According to Lewin, the quality of an object refers to the values that people give to it. Therefore, the quality of objects decreases or changes when they are not according to the values that people give to them. And the influence of that object changes according to needs. According to Gibson, the environment, with its existence, shows something that can be optimally used at the right time, and the affordances of the environment, depending on its opportunities and limitations, provide different invitation qualities (Shahcheraghi and Bandabad 2016, 116).

2.2.3. Theory of Ecological Perception

According to this theory, the facts of the surrounding environment make it possible to create information based on human senses in the real world for the user. These senses correspond to the surrounding environment, such as the gravity of the earth, day and night, which have been unchanged throughout history (Shahcheraghi and Bandabad 2016, 136).

2.2.4. Lynch's Theory of Good City Form

According to Lynch, paths, nodes, districts, landmarks, and edges are the elements making urban spaces legible. These elements are further considered environmental and visual components and can

influence people's wayfinding process (Khome 2016, 72).

2.2.5. Hillier's Space Syntax Theory (Space Syntax and Visibility)

Hanson and Hillier proposed the space syntax theory in 1984. This theory is based on research on how spatial forms communicate. According to this theory, space is considered the primary core of social events. Space Syntax is the principle describing the analysis of the relationship between space and people. In this method, various graphs are applied to describe and analyze spatial patterns in the structure of the city or the intended place (Rismanchian 2010, 50; Hillier, Hanson, and Peponis 1984; Hillier 2005).

Space syntax includes a series of analytical techniques that describe the relationship between space and society (Hillier, Hanson, and Peponis 1984).

In the following, physical sub-branches including landmarks, paths, edges, nodes, light stimulus, spatial sequence, form, color, contrast, environmental components including accessibility, security and surveillance, walkability, legibility, social vitality, and visual components including area, perimeter, enclosure, circularity, contraction, and compaction are investigated. These components are classified based on the subjects' knowledge, perception, and decisions.

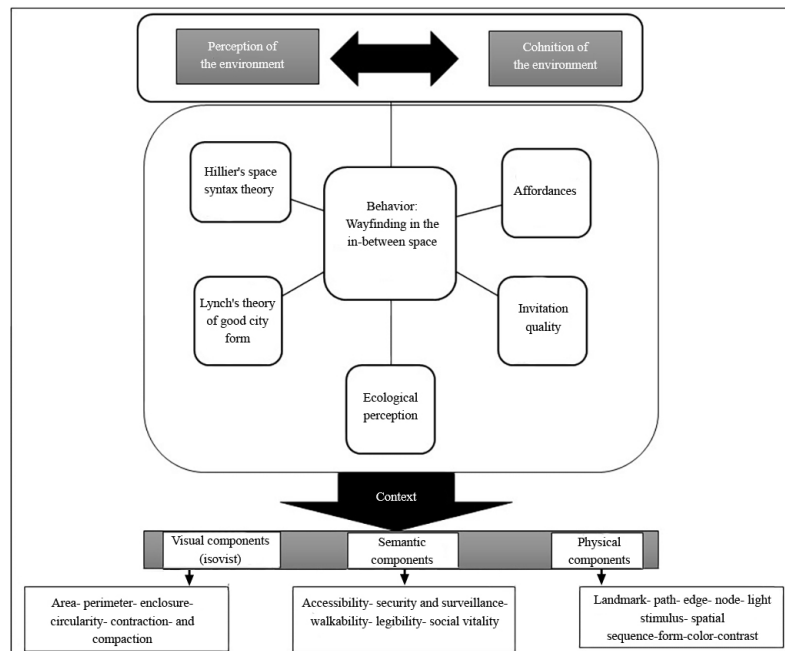


Fig. 4. The Final Model of the Theories used to Obtain the Required Indicators based on Visual Perception in the Context of the In-between Spaces in Residential Complexes

3. THE RESEARCH SCOPE

The study area is Kerman city. According to the research topic, out of several residential complexes, three residential complexes were selected based on

the observation checklist: 1. Fajr residential complex: it consists of 239 residential units and is located on Jomhuri Blvd., Sadeghieh 2 St.; 2. Noon Val Qalam residential complex: it consists of 414 residential units

and is located on Imam Ali Blvd., near Danesh bridge in Kerman city; and 3. Imam Hassan (AS) residential complex: it consists of 200 residential units and is

located on Yadgar-e Imam Highway, Danesh Blvd., Danesh 4 (Fig. 5).

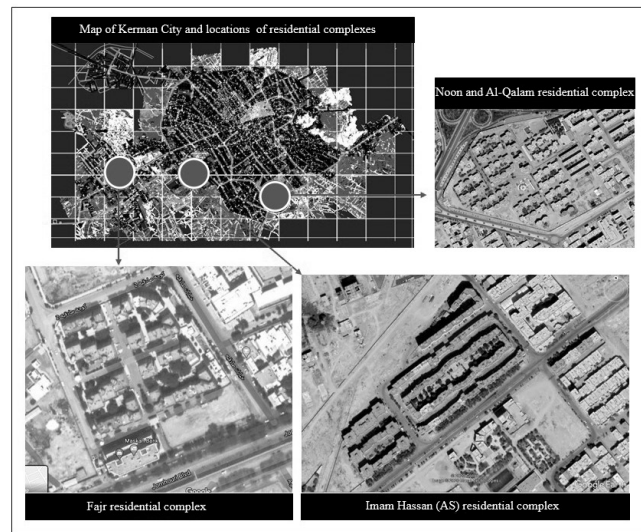


Fig. 5. Research Scope

4. METHOD

The present study is mixed-method research in which quantitative and qualitative the researcher collects quantitative and qualitative data and analyzes them separately. Then, by comparing these results, he/

she judges whether the findings of one approach are confirmed or rejected through the findings of another approach. The main assumption of this method is that quantitative and qualitative data provide different information for the researcher.

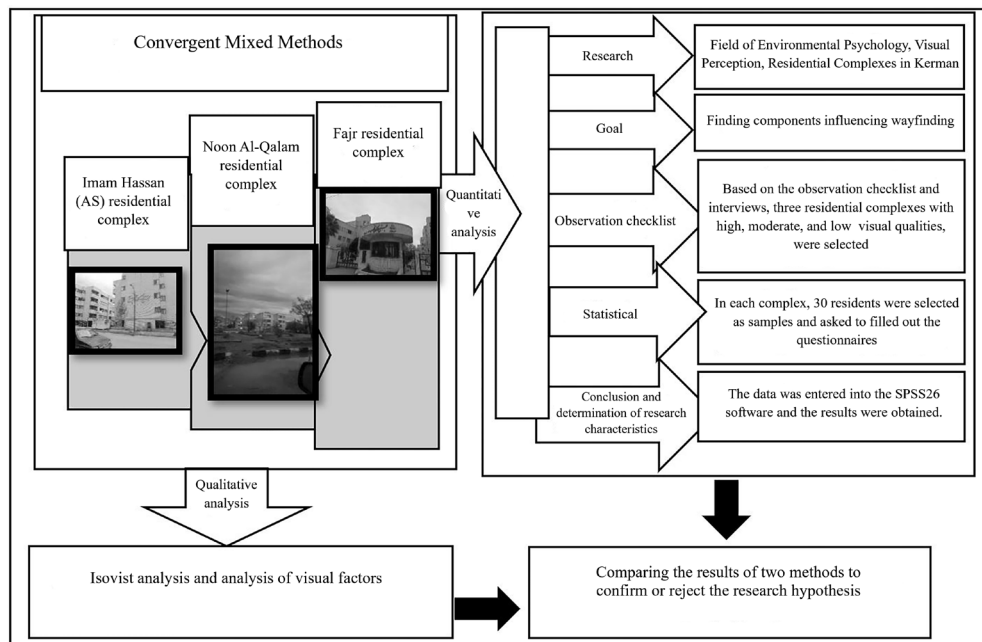


Fig. 6. The Mixed-Method Research Process

Before examining the research hypotheses, the normality of the data of the studied variables should be investigated to find out which method (parametric or non-parametric) should be used to

test the research hypotheses. Normal distribution means that most data points cluster toward the middle of the range (the mean of the range), while the rest taper off symmetrically toward either extreme, and

the distribution graph shows a bell-shaped curve. If the distribution of the variables is not normal, the distribution may lack symmetry and be skewed either left or right. Kolmogorov-Smirnov test is used to investigate normality. Figure 6 describes the research process. Also, the qualitative data were examined and the plans and variables were analyzed in the software. Finally, the results of the two methods abovementioned were obtained (Fig. 6).

In this research, through the survey method, the residents' evaluation of the residential complexes in legibility was analyzed (one complex with low visual quality, one with moderate visual quality, and one with high visual quality). According to the literature review, the physical and semantic components effective in wayfinding were extracted and examined in the three complexes selected. To this end, first, the research scope and the statistical population

were determined. The research scope in the field of environmental psychology included residential environments. By determining the intervening variables and using Morgan's table, 90 people were evaluated with 30-question questionnaires. And the obtained data were analyzed in SPSS software. In this research, Cronbach's alpha was used to determine the reliability of the questionnaire. This coefficient shows the extent to which the questions in a questionnaire overlap and align. The value of this coefficient indicates whether the respondents have answered the questions of the questionnaire with accuracy and knowledge. This coefficient is also used to calculate the internal consistency of the measurement instrument of the questionnaire. In this research, as reported in the inferential statistics section, the reliability of the research tool is as follows (Table 1).

Table 1. Cronbach's Alpha Test to Investigate the Reliability of the Research Tool

Research Variable	Alpha
Environmental Variable	0.71
Human Variable	0.74
Visual Variable	0.73

Since Cronbach's alpha was estimated to be above 0.7 for the abovementioned variables, the items of our research tool (questionnaire) have high internal consistency, indicating that the research tool (questionnaire) has proper reliability. Figure 7 shows

the questionnaire format. This questionnaire was developed in three parts including semantic, physical, and visual components, and the questions related to each part were examined for better assessment.

The general format of the residents' questionnaire based on the Likert scale

**In the Name of God
Questionnaire**

The survey of residents and visitors of theresidential complex to "identify the factors affecting wayfinding in their-between spaces".

Ease of wayfinding in in-between spaces is one of the factors enhancing legibility. For users, wayfinding is a purposeful, directional behavior, and dynamic movement from the origin to the destination and includes interactions between the user and the residential

<p>Components in question: (landmark, node, path, edge, light stimulus, spatial sequence, form, color, contrast) Three questions on each component were asked.</p>	<p>Landmark A1- Is the entrance of the complex in such a way that it can be identified from the surrounding streets? <input type="checkbox"/> Very highly <input type="checkbox"/> Highly <input type="checkbox"/> Moderately <input type="checkbox"/> Slightly <input type="checkbox"/> Very slightly A2. Is there a specific landmark such as traffic signs at the side of the paths between the blocks? <input type="checkbox"/> Very highly <input type="checkbox"/> Highly <input type="checkbox"/> Moderately <input type="checkbox"/> Slightly <input type="checkbox"/> Very slightly</p>	Environmental
<p>Components in question: (Accessibility, security and surveillance, walkability, legibility, social vitality) Three questions on each component were asked.</p>	<p>Accessibility B1- Considering previous questions, how is the accessibility of the desired residential complex from the main street? <input type="checkbox"/> Very highly <input type="checkbox"/> Highly <input type="checkbox"/> Moderately <input type="checkbox"/> Slightly <input type="checkbox"/> Very slightly</p>	Human component
<p>Components in question: (Area, perimeter, enclosure, circularity, contraction, and compaction) Three questions on each component were asked.</p>	<p>Perimeter C1- Is the boundary between the complex and the outside clear? <input type="checkbox"/> Very highly <input type="checkbox"/> Highly <input type="checkbox"/> Moderately <input type="checkbox"/> Slightly <input type="checkbox"/> Very slightly</p>	Visual component (isovist)

Fig. 7. Research Questionnaire

5. DATA ANALYSIS

The data were analyzed both quantitatively and qualitatively. In the quantitative analysis part, the data were analyzed based on parametric tests, and in the qualitative analysis part, the data were analyzed in the form of graphs in the Depthmap software.

5.1. First Part: Quantitative Analysis

In this section, after examining the reliability and normality of the data, the parametric tests of the Friedman test, Tukey post hoc test, and one-sample T-test were used to test the variables, and the first-order confirmatory factor model was used to rank the variables.

5.1.1. Examining the Normality of the Variables

Before analyzing the data, the normality of the indicators and variables should be examined. To this end, the Kolmogorov–Smirnov test was used. This test compares the observed cumulative distribution function of an ordinal variable with its theoretical (expected) cumulative distribution function. In other words, in this test, the distribution of an attribute in a sample is compared with its assumed distribution in the population. If Sig. in this test is >0.05 , it can be concluded that the distribution is normal and parametric tests can be used in this research and vice versa. In the present study, since Sig. is obtained to be >0.05 for all variables, one can conclude that all variables have the normal distribution (Table 2).

Table 2. Examining the Normality of the Distribution of Variables

Research Variable	Kolmogorov-Smirnov Statistic	Sig.
Environmental Variable	0.19	0.09
Human Variable	0.26	0.17
Visual Variable	0.31	0.20

5.1.2. First-Order Confirmatory Factor Model

In the first-order confirmatory factor model, the factor loadings determine the ranking of each component explaining wayfinding in the in-between space. The

greater the factor loading of a component is, the more effective and successful that component is. And those components with smaller factor loadings need to be improved to qualitatively enhance wayfinding in the in-between space.

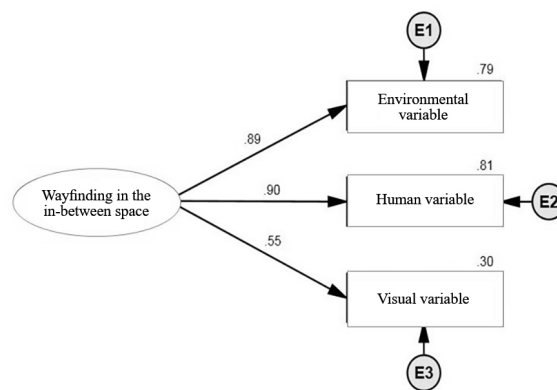


Fig. 8. First-Order Confirmatory Factor Model for Ranking and Explaining Wayfinding in the In-between Space

The above confirmatory factor model prioritizes the components effective in wayfinding as follows:

1. Human variable with a factor loading of 0.90 and a coefficient of determination (R²) of 81%.

2. Environmental variable with a factor loading of 0.89 and a coefficient of determination (R²) of 79%.

3. Visual variable with a factor loading of 0.55 and a coefficient of determination (R²) of 30%.

Table 3. Ranking of the Components of Wayfinding in the In-between Space

Components	Ranking
Human Variable	1
Environmental Variable	2
Visual Variable	3

After finding that the visual variable has the lowest rank among the variables (Table 3), this variable was measured with other tests. The results showed that the visual variable was not at a desirable level in all three

complexes, but in the Noon Val Qalam complex, it obtained a higher ranking and was at a more desirable level in all three tests (Fig. 9).

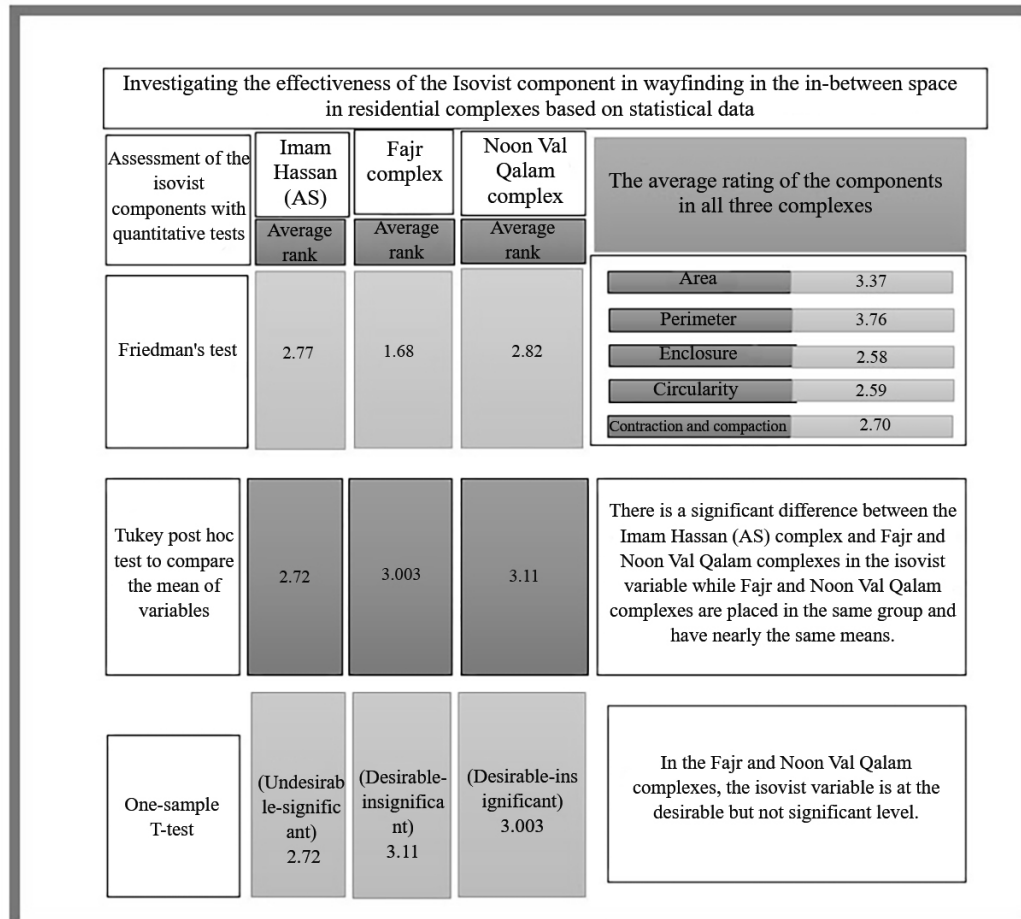


Fig. 9. Comparison of Quantitative Statistical Results in Three Complexes

5.2. Second Part: Qualitative Analysis

In this section, qualitative analyses were performed in the Depthmap software to examine the visual continuity in residential complexes.

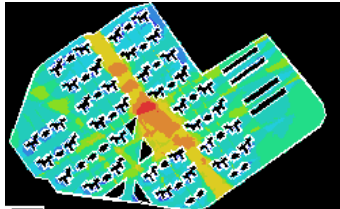

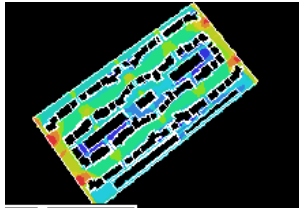
5.2.1. Space Syntax (Visibility Graph Analysis (VGA))

VGA analysis shows the visual connectivity in the complexes. The Depthmap software includes two main methods: Isovist analysis and axis maps. VGA analysis is created with the combination of these two methodologies. Visual connectivity refers to the number of visual steps required to go from one point to another in a system. Therefore, the analysis of visual connectivity shows the extent to which people interact with the space. In general, VGA analysis can describe complex spatial relationships. However, it is limited to two dimensions and the basic idea for the

two-dimensional nature of the Depthmap software is that humans are not flying in space. VGA analysis is a two-step process. In the first step, a set of proper points are determined on the plan. These points are the nodes of the graph. In the second step, the edges are created for the points between which there are direct visual connections. VGA analysis examines the depth of all points in general and shows that the depth of each area is greater or smaller than other areas. In this analysis, the points that are best connected with other spaces appear in red. These spaces have smaller depths. Points with less connection with other areas in the space appear in a cool color spectrum, from green to dark blue.

In general, it can be said that the points that are more visible and have more connection with other areas are places in the warm color spectrum, and the points that are less visible and have less connection with other areas are in the cool color spectrum (Table 4).

Table 4. Comparison of the Three Complexes Studied in VGA Analysis

Comparative analysis of Fajr, Noon and al-Qalam, and Imam Hassan (AS) complexes using the space syntax method			
	Imam Hassan (AS) Complex	Fajr Complex	Noon Val Qalam Complex
VGA Analysis			

According to the analysis, one can say that the entrance of the complex and the spaces related to it are more visible than other areas. There is higher visual connectivity when entering the complex, due to the use of open spaces. Therefore, this space has more connections with other areas. In the case of the Imam Hassan (AS) residential complex, there are the highest visibility and accessibility around the entrances of the complex. In the middle spaces, the visibility and accessibility significantly reduce, and in the central part of the complex, the presence of green spaces has limited the visibility and access, and these spaces appear in dark blue in the Depthmap analysis. The general shape of the Fajar residential complex has caused the two middle spaces to have the highest visibility and accessibility, and the quality of visibility and accessibility of these spaces is also higher than those of the entrance space. But in the side corridors created in the design of the complex, the visibility and accessibility are much less. Middle green spaces are still a significant factor limiting visibility and accessibility.

In the case of the Noon Val Qalam residential complex, it can be concluded that the two axes in this complex have the highest visibility and accessibility. The first axis leads to the middle spaces of the complex and has the highest visibility and accessibility although the entrance of the complex is not located along this direction. The second axis is located along the complex entrance and it has relatively higher visibility and accessibility than other areas. According to this analysis, it can be said that a better position for the entrance of this complex could be the central axis leading to the middle spaces. However, due to the relatively balanced distribution of blocks in this complex and the equal size of the blocks, visibility and accessibility are almost the same in all parts of the complex. There are fewer areas in dark blue in the analysis of this complex, implying the higher quality of visibility and accessibility in this complex than Fajr and Imam Hassan complexes.

6. FINDINGS AND DISCUSSION

In the research process, to explain the relationship between the proposed theories and the wayfinding

of the residents, the studied components were first extracted. In this research, to select the case studies from three weak, moderate, and strong categories, first, residential complexes were classified by the observation checklist. Then, three residential complexes, including the Imam Hassan (AS) complex with a weak component spectrum, the Noon Val Qalam complex with a moderate spectrum, and the Fajr complex with a strong spectrum in Kerman city, were selected as case studies.

The components include environmental (landmarks, nodes, paths, edges, light stimulus, spatial sequence, form, color, and contrast), semantic (accessibility, security and surveillance, walkability, legibility, and social vitality), and visual (area, perimeter, enclosure, circularity, contraction, and compaction) variables.

These components were examined in two areas: 1. the entrance space of the residential complex, and 2. the in-between space and the entrance threshold of the building blocks. Using the first-order confirmatory factor analysis, it was found that the visual variable obtained the lowest rank, so in this study, the visual component, which plays a key role in legibility and wayfinding, was evaluated using the Friedman test, Tukey post hoc test, and one-sample T-test and in all three cases, it was observed that the highest score was obtained for the Noon Val Qalam complex.

In the first area, the effect of components on wayfinding was investigated, especially at the main entrance of the complexes. As seen in Figure 10, the higher the frequency of landmarks and visual variables, the better the residents' wayfinding is. In this area, other components such as color, lighting at night, etc. are also effective. In the next area, the in-between space between the main entrance and building blocks and between the blocks themselves were investigated. There are many factors influencing the wayfinding process in the in-between spaces in residential complexes. Two quantitative and qualitative research methods were used to analyze the found foundations.

Comparing the tables representing the results of both research methods (quantitative and qualitative test results) shows that visual indicators influence the residents' decision-making. In the present study, the evaluations and analyses were carried out for the

built complexes that were operated by the residents (post-operation evaluation). These evaluations can

help designers in pre-operation design (pre-operation evaluation) (Fig. 10).

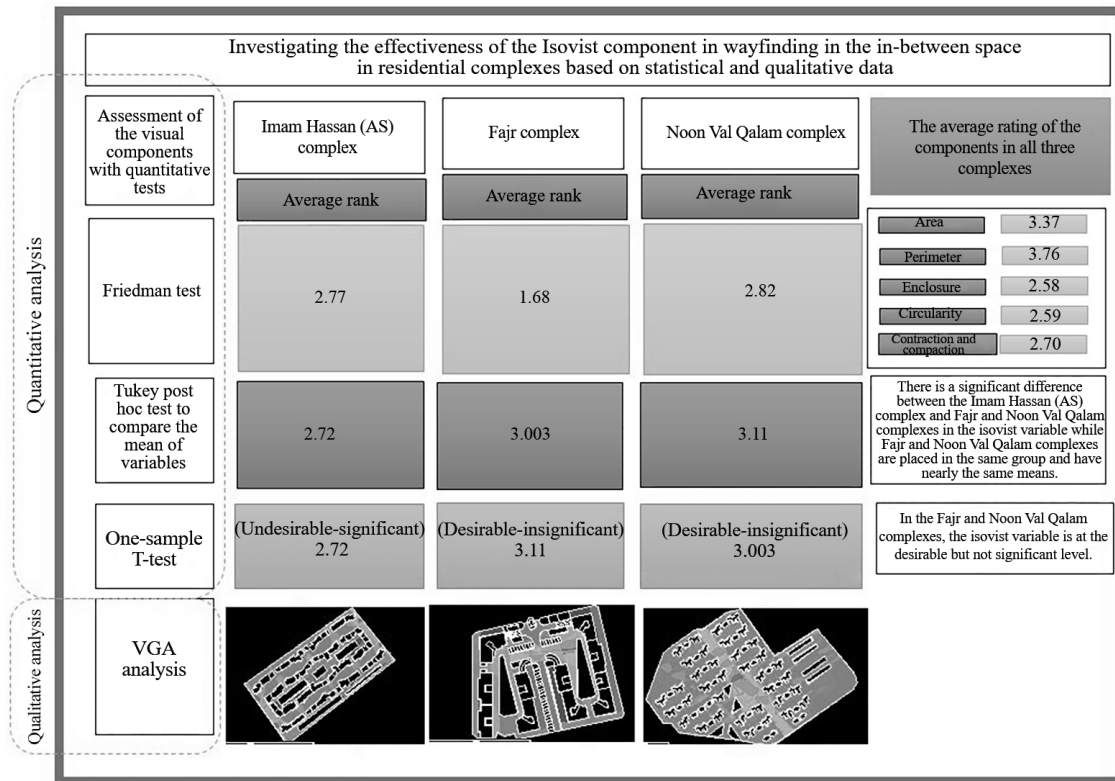


Fig. 10. Comparing the Results of Qualitative and Quantitative Research in Residential Complexes

As seen in Figure 10, comparing the results of quantitative and qualitative research shows that the same results were obtained in the software analysis, and the Noon Val Qalam complex obtained the highest score in terms of visual variables. In the qualitative analysis, VGA analysis shows that, in general, in the two Noon Val Qalam and Fajr complexes, central spaces have higher visibility and accessibility. This is directly related to the design patterns of these complexes. Noon Val Qalam complex has more open spaces and scattered blocks of the same size, causing visibility and accessibility to be the same in most parts of the complex and higher in the central and entrance spaces. About the Fajr complex, it can be said that the middle green spaces act as a factor limiting visibility and accessibility. Better design or the use of low-height vegetation, that does not limit

visibility, will increase visibility in these areas, but will not influence accessibility.

In the Imam Hassan residential complex, there are higher visibility and accessibility in a loop of middle spaces compared to other areas. This issue is due to the absence of visibility barriers in these axes. Therefore, in pre-occupancy design, where the designer does not have access to the residents, he can rely on software analysis results (Fig. 11).

Also, the investigation of the environmental components indicates that the block layout, light stimuli at night, and color are among the important elements in the design of in-between spaces. So, the distance between blocks can influence visual components, and due to the formation of spaces requiring security and surveillance, it also affects human components.

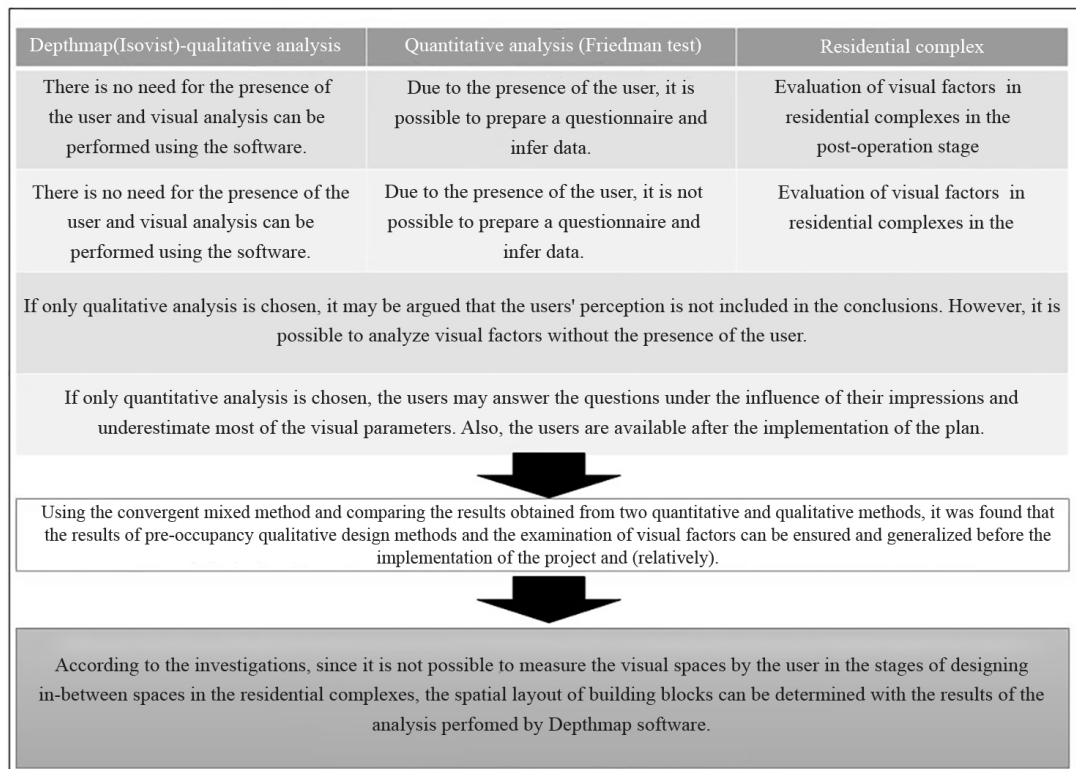


Fig. 11. Description of Quantitative Findings through Qualitative and Quantitative Findings Obtained for the Pre-operation Stage by Cross-Checking Post-operation Results

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