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Influence of aesthetic design elements on residential satisfaction in apartment based on Seoul apartment complex

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ABSTRACT

This study aimed to examine the influence of aesthetic design elements on residential satisfaction in urban apartment complexes, focusing on elements that are generally considered less important. A total of 65 apartment complexes in Seoul, a city predominantly characterized by middle-class apartment living, were surveyed to assess residential satisfaction. Using multiple regression analysis, the relationships between the dependent variable (post-occupancy evaluation) and 28 independent variables were analyzed. The results revealed significant correlations between residential satisfaction and various independent variables. Specifically, three out of eight aesthetic design factors, namely the main complex entrance design, exterior mass design, and landscape design, were found to have a significant impact on residential satisfaction, collectively accounting for 17.16% of the total satisfaction variance. This finding suggests that aesthetic design elements play an increasingly important role in metro cities. The practical implications of this study are twofold. Firstly, it provides housing providers with strategic guidelines, emphasizing the significance of incorporating aesthetically pleasing design elements to enhance residential satisfaction. Secondly, the study offers potential customers valuable information regarding the importance of aesthetic design in their decision-making process when choosing residential properties. Overall, this research contributes to a better understanding of the relationship between aesthetic design elements and residential satisfaction in urban apartment complexes, shedding light on the growing importance of aesthetics in the housing market.

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Aesthetic design element; apartment complex; customer satisfaction; post-occupancy evaluation

1. Introduction

The most fundamental purpose of the building industry is to provide residents with practical protection, psychological stability, and a variety of interior experiences through diverse pursuits, including work, study, and family life, and social connections. All construction-related activities, such as design, planning, construction, and maintenance, have been developed as methods to achieve this purpose. As is the case with other products or industries, the building industry has been developed in accordance with guidelines and specifications established by authorities and professionals who ought to be knowledgeable about the requirements and expectations of clients. As the building is the "product" that humans use (stay) the longest and various social activities take place there, it can be said that user satisfaction with the building is more important than satisfaction with any other product or service. According to Milion et al. (2017), however, while designers in other fields spend considerable resources investigating customer satisfaction to refine the quality and functionality of products, building professionals do not seem enthusiastic about reflecting residents' satisfaction.

In general, satisfaction refers to a person's feelings of pleasure or disappointment in a specific situation or object in relation to his or her expectations. Satisfaction represents an overall customer's emotional response to a product or service, i.e., one that is better than anticipated owing to the fulfilment of some needs, goals, or desires (Hansemark and Albinsson 2004). Customer satisfaction has a huge impact on a company's present and future performance since it depends on the quality of its goods and services (Hassan et al. 2015; Leninkumar 2017; Lewin 2009). This is a key issue for all companies aiming to create and maintain a competitive advantage in this highly competitive world. As a result, all businesses sectors have examined consumer satisfaction in great detail, including manufacturing, home appliances, electronics, and automobiles. Even in the building industry, customer satisfaction is becoming increasingly crucial. As a key to promoting the construction process and customer relationship, residential satisfaction can be seen as either a quality development goal or a measurement tool for a building function.

This study focuses on residential buildings to investigate and study residential satisfaction in depth, as

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buildings are the places where people stay the longest and represent the most expensive product that people purchase. Evaluating residential satisfaction provides critical information for decision-making regarding improvements to the current housing stock and for the design and development of future projects. Conventionally, when evaluating residential satisfaction, physical functions (such as structural robustness or convenience in use) have been considered significant criteria for residential buildings. However, unlike in other types of buildings, residential satisfaction in residential buildings can be influenced by other factors, such as the residential environment, public transport, and psychological tranquility, all in consideration of living for 24 hours and the dwellings of children and the elderly. This implies that residential buildings should fulfil residents' everyday requirements and goals while also enhancing the built environment's aesthetic value.

Understanding customer needs is becoming increasingly difficult, mostly as a result of the complexity of the value systems of each user category nowadays. Residents' needs, expectations, and desires are incorporated into both physical functions and spatial configurations, including aesthetic design. Aesthetic elements can complement physical functions to provide an aesthetically pleasing environment that meets individuals' tastes, psychological needs, and social status. Aesthetic elements in residential buildings may be expressed through a variety of architectural designs and characteristics. These include the building design, unit plan, materials, and spatial configuration, and the integration of these elements with physical functions can influence the overall aesthetic response and, correspondingly, the satisfaction of residents (Ghomeshi and Jusan 2012). Building aesthetics are more than just an abstract aesthetic phenomenon; their satisfaction depends on the psychology and assessment of those who regularly experience them and is based on producing an impression that meets the residents' physical, emotional, aesthetic, psychological, and intellectual needs (Akinbogun, Aigbbavboa, and Gumbo 2020). However, the majority of satisfaction studies on residential buildings have focused on physical functions or the residential environment (Egemen 2020; Forsythe 2007; Meenakshi 2016; Sweis et al. 2013; Thaddi and Admane 2015). Very limited research has been conducted on aesthetic design elements, which could be another axis contributing to the residential environment. From this perspective, to understand the increasingly complex value standards of residential buildings and conduct an integrated residential satisfaction study, this research aims to appraise how aesthetic design elements contribute to the residential environment and residential satisfaction of apartments in Seoul, South Korea. To this end, selected residential buildings in Seoul were investigated to assess the residential satisfaction with the physical, spatial, location, and aesthetic contributions.

2. Literature review

2.1. Residential satisfaction research

Studies on consumer satisfaction take into account a variety of fields in the built environment, social sciences, and management. Although the concept of customer satisfaction originated in the realm of marketing, it is generally known that over the past few decades, significant progress has been made in regard to built environments, particularly in the housing industry. Residential satisfaction studies have been demonstrated to be crucial instruments for evaluating technical performance and comprehending people's attitudes, requirements, and expectations of the building-in-use (Ibem et al. 2013). According to existing research, several factors connecting to the physical characteristics, building performance, and local environment of the apartment complex influence customer satisfaction in residential buildings; thus, it is a multidimensional concept (Forte and Russo 2017; Mohit, Ibrahim, and Rashid 2010).

Regarding the physical characteristics of residential buildings, Vischer (2001) offered a loose definition of a post-occupancy evaluation (POE). Normally, residential satisfaction studies assess physical building conditions, i.e., how satisfied building users are with the environment and performance of the building. Ibem et al. (2013) assessed the performance of residential buildings in Nigeria's public housing. Using structured questionnaires and observations, they assessed the living conditions of dwelling units, such as the number of bedrooms, state of repairs, window types, or floor finishes. The satisfaction levels were generally higher with privacy and with the sizes of living and sleeping areas than with the availability of water and electricity in the buildings. All 27 of the evaluated building attribute factors were physical functions, such as bedroom size, living room size, air quality, building type, and protection against noise. Among these, the unit type, location, and size of the main activity areas were the most predominant factors. Fatoye and Odusami (2009) also reported similar results to those of Ibem et al. In public housing in Lagos, Nigeria, the most critical elements influencing residential satisfaction were building features such as the number of rooms, ceiling heights, and locations of the different rooms in their dwelling units.

Another dominantly studied topic is the performance of a building, in which the range of factors affecting residential satisfaction has widened and become more complex. Thaddi and Admane (2015) insisted that success in a residential project directly depends upon the satisfaction level of the residents

with performance conditions. Nevertheless, sometimes standards and specifications for performance do not conform to the changing needs and expectations of users in the Indian construction industry. They investigated different defects with potential negative impacts on the degree of residential satisfaction and focused more on aspects of the building's construction status (which is related to the performance), such as tile debonding, the staining of ceiling boards, staining at fittings, or water leakages. They argued that the dominant factor influencing customer satisfaction was the practical building usability rather than the spatial configuration (which was more related to the psychological stability or aesthetics of the design). Interestingly, this trend of research focused on building performance is also seen in other Indian residential building studies (Piyush, Bhatt, and Pitroda 2016; Roshan et al. 2017), and the factors (unit size or location of the building) affecting residential satisfaction are also similar.

To assess the complex factors of residential buildings, Yau et al. (2009) created the building quality index (BQI) and included building variables that suited the institutional and cultural surroundings of flats in Hong Kong, where physical function factors (unit size, plan shape, headroom, windows, noise reduction, and visual obstruction) and building performance factors (thermal comfort, cleaning, pest control, refuse handling, drainage condition, unauthorized alteration, and water quality) were evaluated together. Furthermore, they tried to consider various factors affecting residential satisfaction, including external environmental factors ("density, adjacent use, air quality, aural quality, visual obstruction, and thermal comfort"), operations and maintenance ("cleaning, pest control, refuse handling, wastewater system, unapproved adjustment, and water quality"), and management approaches ("owner duties, documentation, and emergency preparedness"). Forte and Russo (2017) also evaluated user satisfaction in public housing in Naples (Italy). After analyzing the performance of a building "in use" through a combination of objective and subjective desires of the occupiers, they insisted that improving the quality of living ("quality of community spaces" and "internal common spaces") as related to the building's performance was as important as the building's physical function ("quality of dwellings"). From a similar perspective, Orihuela and Orihuela (2014) found that in Latin American countries, the surroundings or neighborhood may have a greater impact on residential satisfaction than the housing itself (building physical functions) (Türkoğlu et al. 2019; Wongbumru and Dewancker 2016).

In contrast to conventional methods that primarily concentrate on the physical conditions or operational aspects of residential buildings, new types of residential satisfaction surveys integrate diverse complex standards such as POE or BQI. These approaches seek to assess the quality and reliability of the services provided. They actively explore the emotional and social elements that may be influenced by the physical functions or building performance, as well as their interconnectedness. By considering the intricate components of the residential environment, research on customer satisfaction can provide a means to understand the interaction between apartment features and users' preferences, as well as suggest strategies to improve the environment in a way that fulfills both user needs and supplier capabilities (Adedayo et al. 2013; Da Silva et al. 2020). As human lifestyles have become more complex, various types of housing have been developed, including high-rise apartments, mixed-use buildings, and large apartment complexes. With advancements in construction technology, residential satisfaction is gradually shifting from traditional criteria, such as physical functionality and performance, to encompass softer aspects like psychological stability and practical safety (Ettema and Schekkerman 2016; Li and Wu 2013; Scannell and Gifford 2017; Wilde 2018). Roessler et al. (2022) conducted a study on the impact of the exterior design of houses on the environmental stability of residents. Their research, based on 50 residential façades in Canada, found positive effects such as "Friendship," "Likability," and "Invitingness." Although this study focused on detached houses rather than apartments, it demonstrated that the shape (façade) or design of a house can influence the psychological stability of its residents. Recognizing psychological stability as a crucial factor in housing, particularly for urban residents, Wang et al. (2019) developed the "Urban Residents Psychological Security Scale." They analyzed over 20 psychological indicators related to urban life as factors contributing to residential satisfaction. While research on the psychological stability of residents is ongoing, it tends to focus more on general housing rather than apartments, and urban studies are predominantly conducted on a broader scale.

However, research on residential satisfaction in apartment complexes has been predominantly focused on physical functions and building performance, thereby neglecting other important factors. These studies fail to address the industry's need to incorporate customer or user preferences into projects, and they can also lead to increased costs by including unnecessary or excessive facilities. In particular, aesthetic design elements, including the appearance of the building, its shape, interior design, materials, and color schemes, have often been treated as secondary sub-elements rather than being recognized as primary factors in customer satisfaction (Akinbogun, Aigbbavboa, and Gumbo 2020; Jansen 2012; Opoku and Muhmin 2010; Torbica and Stroh 2001) or simply as a factor in housing value from the real estate perspective (Abidoye and Chan 2016; Bangura and Lee

2019; Bouras, Hoesli, and Sun 2005; Elam and Stigarll 2012). In addition, unlike in Asian metro cities such as Seoul or Shanghai, where apartments are recognized as luxurious or at least above the middle-class housing type (Hirsh 2015; Lewis, Martin, and Sun 2012; Wu et al. 2020), in many Western countries, apartments are mainly used as houses for low-income people, such as public houses. Thus, the critical indicators of residential satisfaction have been developed mainly to consider substantive factors for the building's function or performance, and aesthetic elements have been excluded (Ilbeigi and Ghomeishi 2017). In a small number of studies (Pastore and Andersen 2022; Roulac 2007; Voordt and Wegen 2005), aesthetic elements have been described in the context of general aspects of quality, such as functional (building efficiency), symbolic, and cultural value. However, the direct effects of aesthetic design elements on residential satisfaction have not been significantly studied.

2.2. Changes in consumer satisfaction of Seoul apartment

For several decades, Seoul's fast urbanization and modernization have caused a significantly larger rise in housing demand than in other cities. The majority of attempts to satisfy this need have been focused on solutions for the housing deficit in terms of quantity. In particular, when the first new towns of approximately 300,000 households were built on the outskirts of Seoul in the early 1990s, a large number of apartment complexes with almost the same designs were built, so as to build the necessary housing in a short time (Joo 2012; Kim and Kim 2016). The majority of problems tackled by home providers have been related to housing supply, with no attention being paid to the needs and desires of the end home client. Therefore, the designs that have been provided are generic, and the aesthetic elements for residential satisfaction have not been considered. As a result, the same-shaped matchbox-like apartment complexes (see Figure 1) have been endlessly reproduced, prioritizing the construction of efficient and economical housing complexes rather than the social relationships or psychological stability of the residents. Since the 2000s, the focus of building operations has increasingly switched from housing quantity to housing quality as a result of improvements in the qualitative demand for housing (Jun 2012; Lee and Yoon 2019).

Figure 1. Matchbox-like apartment complexes in Korea (source: Korea JoongAng Daily).

A standard for residential satisfaction reflects national policies, lifestyle, culture, and norms. In Seoul, the factors affecting residential satisfaction in apartments have changed rapidly in response to changes in the residential environment. In the 1990s, the focus was on convenience facilities in the complex; in the 2000s, it was on surrounding infrastructure elements such as education and transportation; and after 2010, as apartments became more luxurious, psychological tranquility and the unique designs of apartment complexes became more important. Accordingly, various studies have been conducted to analyze the effects of specific factors on residential satisfaction. In South Korea, including Seoul, as an apartment is considered as a high-income residential type, physical functions such as the unit floor plan, convenience facilities, views, and parking within the complex (Ahn and Kim 2018; Hwang and Ha 2015; In and Oh 2020; Sohn and Ahn 2022; Yang et al. 2018) or social and psychological factors including regional safety, public transportation, and surrounding educational and commercial facilities (Kim, Pack, and Kim 2016; Ha 2008; Jun and Jeong 2018; Koo and Cho 2015; Lee 2016; Shim et al. 2014) have been studied as critical satisfaction factors, rather than those concerning building performance (water quality, inter-floor noise, insulation). In addition, owing to Korea's unique culture and lifestyle, the orientation of the main living room, Internet access and home network, and educational environment (such as adjacency to prestigious schools or private academies) have also emerged as factors with important influences on residential satisfaction in apartment complexes (Baek and Joo 2021; Kim et al. 2005; Lim and Lee 2016). The quality and value of residential buildings in Seoul cannot be evaluated using only physical functions or building performance; thus, alternative indicators, such as the price per square meter or brand of apartment complex, can be used to supplement them. The analysis of the aesthetic design elements of the complex can provide a supplementary option for evaluating residential satisfaction in Seoul. In recent years, various design elements such as landscape designs, exterior designs, facade color schemes, and rooftop and entrance designs have been used as main marketing factors for residential buildings (see Figure 2). Therefore, research on satisfaction with aesthetic design value will help to increase the overall quality of residential buildings and in the development of strategies for housing development.

Figure 2. Aesthetic design elements in Seoul apartment complex (source: SAMSUNG C&T Corp).

3. Research methodology and data collection

Based on the literature review, the relationships between aesthetic design elements and residential satisfaction and the degree of influence of the individual aesthetic design factors were deduced using a multiple regression analysis. The research data for the objective analysis were obtained from Korean government (Ministry of Land, Infrastructure and Transport, South Korea). The "Satisfaction Survey on Residential Environment" (2020) was used as the survey for residential satisfaction, and the Real Estate Transaction Disclosure System (http://rt.molit.go.kr/) was used for the evaluation of market value of an apartment. Based on this government data, various evidential information was analyzed by conducting actual site investigations and detailed reviews of the completion drawings of each apartment complex from autonomous borough offices. Although the purpose of this study was to evaluate the influences of aesthetic design elements on residential satisfaction, it also focused on physical functions, building performance, and regional features as main categories for objective analyses of different variables, as shown in Table 1.

The target data were obtained from apartment complexes with more than 1,000 households built in Seoul after 2015. Accordingly, 63 apartment complexes located in 25 autonomous boroughs in Seoul were selected as the sample. Residential satisfaction is indeed a subjective measure, as it is influenced by individual preferences and standards of beauty. Given the diverse design elements applied to apartments, this study aimed to examine the variability of aesthetic design elements by conducting a resident survey where participants could select their preferences (0 or 1). The analysis of satisfaction levels was based on the "Satisfaction Survey on Residential Environment," which is a government-conducted survey focusing on residential satisfaction. In addition to the subjective survey data, objective data such as the market value of apartments within the same area were included for further analysis. This combination of subjective and objective data provides a comprehensive understanding of residential satisfaction in relation to aesthetic design elements. The residential satisfaction for each of the 63 apartment complexes was obtained by reflecting the price per square meter of the housing unit (from the Real Estate Transaction Disclosure System) based on the individual residential satisfaction figures of 25 autonomous boroughs. Most Korean apartments are 59 m^2, 84 m^2, and other units receiving incentives from the government, such as tax reductions. The Korean government encouraged the construction of apartment units with relatively standardized sizes and prices (59 m^2 and 84 m^2 type) in order to provide as many units as possible in a short period of time. Consequently, within the same apartment complex, the prices of individual units of the same size are approximately the same. In contrast, depending on the apartment complex to which a unit belongs, it may have a different price per square meter even if the unit size (exclusive area) is the same. Therefore, along with the subjective residential satisfaction figures of the individual autonomous boroughs, the unit prices per square meter can be used as an objective indicator to determine the consumer satisfaction within a target apartment complex. For evaluation under the same conditions, only apartment complexes with at least four aesthetic design elements in Table 1 were included. The basic statistics for the 63 samples are presented in Table 2.

4. Data analysis and research finding

Among the various aesthetic elements, only the specific variables potentially affecting residential satisfaction were collected, and the degrees of influence of the individual variables were analyzed. These were the criteria for which the variables were considered when evaluating the value

Table 1. Residential satisfaction variable.

Category	Factor (variable)	Criteria
Physical function	Unit size	(m^2)
	Building direction	Southward located: 1, South-east & South-west located: 0
	Total number of households	
	Floor Area Ratio	Ground floor area/Area of the plot (%)
	Number of floors	Average number of floors
	Public green space	Landscaping area/Area of the plot (%)
Building performance	Parking convenience	Total number of parking lots/Total number of households (%)
	Children playground	Playground area/Ground floor area (%)
	Noise pollution	Heavy-weight impact sound barrier performance level 1: 1, Other rest: 0
	Thermal comfort	Coefficient of thermal transmission of household exterior walls ($w/m^2 \cdot K$)
	Community facilities	Total area of community facilities/Ground floor area (%)
Regional feature	Public transportation	Distance from the underground station (m)
	Adjacent park	Distance from adjacent park (m)
	Adjacent educational facilities	Number of schools within a radius of 500 m
	Adjacent commercial facilities	Distance from adjacent department stores or supermarkets (m)
	Adjacent public facilities	Number of public facilities within a radius of 500 m (police stations, fire stations, community centre, library, etc.)
Aesthetic design	Exterior mass design	Entrance, stairwell, sidewall design: 1, Other rest: 0
	Rooftop design	Rooftop landscape structure design: 1, Other rest: 0
	Material design	Exterior stone cladding, aluminium sheet, Interior stone finish: 1, Other rest: 0
	Main complex entrance design	Main gate landscape structure, gatekeeper house: 1, Other rest: 0
	Lighting design	Integrated lighting design (Main gate, rooftop, sidewall, passageway, landscape): 1, Other rest: 0
	Landscape design	Art sculpture, promenade, street furniture, themed garden: 1, Other rest: 0
	Colour scheme	Consistent colour scheme (signage, pictogram, façade, theme colour): 1, Other rest: 0
	Waterscape design	Biotope, Pond, Fountain, stream, waterfront space: 1, Other rest: 0

of aesthetic designs in residential buildings. The specific analysis method for the aesthetic design variables was as follows. First, a residential satisfaction model was established using the different characteristic variables affecting residential satisfaction, and the Statistical Package for the Social Sciences (SPSS) 26 was used for statistical analysis. This study utilized a multiple regression analysis to verify the different independent variables, particularly the aesthetic design variables. In addition, as a statistical technique, multiple regression analysis was used to examine the relationship between a dependent variable and numerous independent variables (Gaur and Gaur 2013; Kafle 2019). In this study, the residential satisfaction was set as the dependent variable, and the physical function, building performance, regional features, and aesthetic design variables were analyzed as the multiple independent variables. Second, the multicollinearity and residuals were reviewed to determine the suitability of the model (corresponding to the basic assumptions of the regression analysis). Third, a regression model was derived by logarithmically converting the dependent or independent variables, and an optimal model was selected by comparing them with a linear regression model.

4.1. Aesthetic design variables affecting residential satisfaction

All of the independent variables expected to influence the level of residential satisfaction were analyzed using multiple regression analysis. However, as it was found that the initial regression analysis did not form an alignment, a linear regression equation was derived after logarithmically converting the variables. In the regression model, as shown in Table 3, the coefficient of determination (R^2) is 0.885 and the adjusted R-square value is 0.847. This indicates that there are meaningful interrelationships between the dependent variable and independent variables. The variance analysis shows that the model is valid because the P-value is 0.001, i.e., statistically significant at a significance level of 0.05. In addition, the mean of the standardized residuals is 0.031, indicating that the regression equation satisfies the basic form. As a result of a scatterplot analysis, the data is shown to be equally dispersed as the plots of the independent variables are randomly distributed around 0 of the standardized residuals on the Y-axis. In the Kolmogorov-Smirnov test, the P-value is 0.104 (greater than the significance level of 0.05), indicating that the null hypothesis (the residual distribution forms a normal distribution) is acceptable.

In order to investigate the impact of aesthetic features on residential satisfaction, the study treated eight aesthetic design elements as a single variable and analyzed them in Table 4. The multiple regression analysis results indicated that the aesthetic feature, along with other factors such as unit size or parking convenience, had a significant effect on resident satisfaction. Therefore, in the subsequent stage of the study, the practical impact of each of the eight aesthetic design elements was further analyzed in relation to residential satisfaction. As a result, the significantly derived independent variables influencing

Table 2. Basic statistics of apartment complexes.

Category	Factor (Variable)	Minimum value	Maximum value	Mean value	standard deviation
Physical function	Unit size	49.15	170.32	84.21	61.923
	Building direction	0	1	0.46	0.482
	Total number of households	1005	9510	1326	1066.442
	Floor Area Ratio	150	369	277.603	37.917
	Number of floors	22	43	29.48	6.1354
	Public green space	21.05	46.92	33.93	9.2194
Building performance	Parking convenience	103.27	182.06	116.90	21.723
	Children playground	0.6915	1.3208	0.7704	0.2352
	Noise pollution	0	1	0.72	0.3349
	Thermal comfort	0.15	0.21	0.198	0.1283
	Community facilities	4.29	12.83	7.65	1.895
Regional feature	Public transportation	12.5	1536.4	534.7	293.838
	Adjacent park	18.4	2241.8	471.3	331.279
	Adjacent educational facilities	1	6	2.38	0.8992
	Adjacent commercial facilities	8.3	3411.6	1818.7	823.774
	Adjacent public facilities	0	4	1.63	0.899
Aesthetic design	Exterior mass design	0	1	0.93	0.216
	Rooftop design	0	1	0.72	0.336
	Material design	0	1	0.68	0.429
	Main complex entrance design	0	1	0.77	0.305
	Lighting design	0	1	0.53	0.388
	Landscape design	0	1	0.64	0.402
	Colour scheme	0	1	0.59	0.381
	Waterscape design	0	1	0.42	0.590

Table 3. Results of variables of the linear regression model (I).

	R	R^2	Adjusted R^2	Std. Error of the Estimate	
Regression model	0.902	0.885	0.847	0.11048	
Variance analysis	Sum of squares	df		F	P-value
Regression	58.169	6	7.219	227.923	0.001
Residual	6.104	198	0.17		
Total	64.273	204			
		Kolmogorov-Smirnov			
Residual Normality Test	Standardized residual	Statistics	Degree of freedom	P-value	
		0.031	207	0.104	

Table 4. Results of coefficients (I).

	Unstandardized Coefficients		Standardized Coefficients			Multicollinearity	
Variables	B	Std.	Beta	t	P-value	Tolerance	VIF
Constant	7.190	0.048		87.309	0.001		
Unit size	0.028	0.003	0.704	23.801	0.000	0.829	1.220
Public transportation	- 0.002	0.000	- 0.519	- 9.807	0.000	0.540	1.177
Floor Area Ratio	- 0.012	0.001	- 0.228	3.009	0.000	0.631	1.108
Parking convenience	0.023	0.000	0.042	5.736	0.002	0.774	1.433
Total number of households	0.005	0.013	0.125	3.804	0.000	0.818	1.630
Aesthetic design (8 factors)	0.062	0.033	0.075	3.558	0.000	0.731	1.294
Adjacent educational facilities	0.129	0.007	0.224	2.921	0.003	0.809	1.692
Adjacent public facilities	0.054	0.000	0.055	3.334	0.000	0.638	1.821

the dependent variable (residential satisfaction) are the unit size, public transportation, noise pollution, parking convenience, total number of households, rate of applied aesthetic design factors, adjacent educational facilities, and adjacent public facilities, as shown in Table 4. The regression model indicates that there is no multicollinearity because all variance inflation factor values for the multicollinearity tests are less than 2 (not exceeding 10).

As a result of the regression model analysis, the variable that has the greatest impact on residential satisfaction for apartment complexes is the unit size. In addition, the application rate of the aesthetic design factors has a significant impact on the residential satisfaction (dependent variable) with other independent variables, in the order shown in Table 4. The estimated regression equation derived from the analysis is as follows:

$$\text{In Residential satisfaction} = 7.190 + 0.028 \times \text{Unit size} - 0.002 \times \text{Public transportation} - 0.012 \times \text{Floor area ratio} + 0.023 \times \text{Parking convenience} + 0.005 \times \text{Total number of households} + 0.062 \times \text{Application of aesthetic design factors} + 0.129 \times \text{adjacent educational facilities} + 0.054 \times \text{adjacent public facilities} \quad (1)$$

When the other variables are kept constant, the residential satisfaction level increases by 2.8% for every 1 m^2 increase in unit size (exclusive area). Whenever the parking convenience rate increases by 1%, the residential satisfaction level increases by 2.3%, and every time the number of households increases, the satisfaction level increases by 0.5%. The analysis results show that with every addition of one educational and public facility within 500 m of the apartment complex, the residential satisfaction level increases by 12.9% and 5.4%, respectively. On the contrary, for every meter further away from the underground station, residential satisfaction decreases by 0.2%, and as the floor area ratio increases by 1% (denser), residential satisfaction decreases by 1.2%. Regarding the aesthetic design variables, there is a 6.2% rise in residential satisfaction for every additional aesthetic design feature used in the apartment complex. The results from this analysis indicate that the application of aesthetic design elements significantly influences residential satisfaction associated with Seoul apartments. However, only eight aesthetic design elements were evaluated in this analysis. This is because design elements other than these eight variables are rarely used in luxurious apartments, let alone in ordinary apartments in Seoul.

4.2. Differences in the impact of individual aesthetic design variables

From the results of the multi-regression analysis in the previous section, it is found that the greater the number of applied aesthetic design elements, the higher the residential satisfaction. This section analyzes in detail which of the eight aesthetic design variables influence the residential satisfaction. The impact analysis of the aesthetic design variables was determined as being non-linear; thus, a regression analysis was performed after the log conversion of the variables. Both the dependent variables (residential satisfaction) and all independent variables were log-converted and analyzed again.

As seen in Table 5, the coefficient of determination (R^2) is 0.929 and the adjusted R-square value is 0.767; this can be interpreted as a significant regression with a high probability. The average of the standardized residuals is 0.045, indicating that the regression analysis rejects the null hypothesis. When analyzing the scatterplot, the variable plots are distributed at random based on standardized residuals (0 value) on the Y-axis. In addition, the distribution of the residuals constitutes a normal distribution because in the Kolmogorov-Smirnov test, the P-value is 0.084, i.e., greater than the significance level of 0.05.

From the results of the regression analysis in Table 6, the constant value of the multi-regression model is 5.298, and from the variance analysis, the p-value is 0.000. Thus, the regression analysis can be recognized as statistically significant. The most influential variable for the residential satisfaction in Seoul apartments is unit size (exclusive area). Due to the special characteristics of Korean apartments (units of almost the same design and size, known as the "matchbox"), the unit size might be considered as the most critical factor influencing residential satisfaction relative to other factors such as the complex size, community facility, or location. In addition, when eight aesthetic design variables are analyzed, three of them (main complex entrance design, exterior mass design, and landscape design) are found to have a significant relationship with residential satisfaction. Including the remaining five aesthetic design variables, this study considered other categories such as physical function and building performance.

Table 5. Results of variables of the linear regression model (II).

	R	R^2	Adjusted R^2	Std. Error of the Estimate	
Regression model	0.837	0.929	0.767	0.15377	
Variance analysis	Sum of squares	df		F	P-value
Regression	67.773	8	6.038	245.029	0.000
Residual	7.561	212	0.088		
Total	75.334	220			
		Kolmogorov-Smirnov			
Residual Normality Test	Standardized residual	Statistics	Degree of freedom	P-value	
		0.045	216	0.084	

Table 6. Results of coefficients (II).

	Unstandardized Coefficients		Standardized Coefficients			Multicollinearity	
Variables	B	Std.	Beta	t	P-value	Tolerance	VIF
Constant	5.298	0.316		16.926	0.000		
ln Unit size	1.129	0.022	0.529	18.920	0.036	0.599	1.468
ln Public transportation	- 0.729	0.038	- 0.469	- 12.088	0.000	0.606	1.339
Noise pollution	0.457	0.065	0.224	8.807	0.000	0.553	2.237
Main complex entrance design	0.262	0.044	0.199	3.395	0.027	0.748	1.136
ln Parking convenience	0.083	0.167	0.185	2.091	0.000	0.336	1.448
ln Total number of households	0.138	0.029	0.165	3.772	0.000	0.510	1.362
Exterior mass design	0.077	0.050	0.131	3.649	0.030	0.483	1.400
Building direction	0.194	0.037	0.122	2.295	0.004	0.781	2.539
ln Community facilities	0.052	0.011	0.077	2.077	0.011	0.539	1.336
ln Adjacent educational facilities	0.162	0.046	0.073	3.212	0.000	0.488	1.208
Landscape design	0.285	0.022	0.063	2.870	0.000	0.350	2.082
ln Adjacent public facilities	0.085	0.067	0.058	3.334	0.007	0.474	2.221

Table 7. Degree to which variables affect residential satisfaction.

Variables	Standardized Coefficients	Residential satisfaction (%)
ln Unit size	0.529	23.05
ln Public transportation	- 0.469	20.43
Noise pollution	0.224	9.77
Main complex entrance design	0.199	8.69
ln Parking convenience	0.185	8.04
ln Total number of households	0.165	7.21
Exterior mass design	0.131	5.72
Building direction	0.122	5.30
ln Community facilities	0.077	3.34
ln Adjacent educational facilities	0.073	3.17
Landscape design	0.063	2.75
ln Adjacent public facilities	0.058	2.53
Total	2.295	100.00

However, factors that showed a non-significant relationship were not included in Table 6 due to space constraints in the research paper. Since these factors had a low correlation with residential satisfaction, analyzing their co-effects and p-values would have been meaningless. As a result, the study focused primarily on the 12 factors that were identified as important and demonstrated a significant relationship with residential satisfaction. The estimated regression equation derived from the analysis is as follows:

$$\ln \text{residential satisfaction} = 5.298 + 1.129 \times \ln \text{unit size} - 0.729 \times \ln \text{public transportation} + 0.457 \times \text{noise pollution} + 0.262 \times \text{main complex entrance design} + 0.083 \times \ln \text{parking convenience} + 0.138 \times \ln \text{total number of households} + 0.077 \times \text{exterior mass design} + 0.194 \times \text{building direction} + 0.052 \times \ln \text{community facilities} + 0.162 \times \ln \text{adjacent educational facilities} + 0.285 \times \text{landscape design} + 0.085 \times \ln \text{adjacent public facilities} \quad (2)$$

Among the 28 independent variables, the above 12 variables are significantly related to residential satisfaction. As shown in Table 7, the exclusive area (unit size, 23.05%) and distance from the underground station (public transportation, 20.43%) are the most critical. However, distance from public transportation negatively affects residential satisfaction. As this study considered the underground transportation as the main public transportation method (it is mainly used by approximately 10 million Seoul citizens) and the entire city is densely connected by 17 underground routes, people living closer to an underground station may feel a higher level of residential satisfaction. When it comes to aesthetic design elements, out of the eight variables, only the following three elements are analyzed as significant: the main complex entrance design (8.69%), exterior mass design (5.72%), and landscape design (2.75%). Their total percentage was 17.16, making it clear that they had a remarkable effect on the overall residential satisfaction.

5. Conclusion

This study aimed to analyze residents' perceptions and levels of satisfaction with their residential buildings, with a particular focus on the theoretical understanding and practical application of residential satisfaction in Seoul apartment complexes. By examining the relationship between residents' perceptions and various independent variables, including physical function, building performance, regional features, and aesthetic design elements, practical results were obtained through multiple regression analysis. The findings of this study highlight the importance of aesthetic design elements in influencing residential satisfaction. Along with other factors such as unit size, public transportation, noise pollution, parking convenience, total number of houses, adjacent educational facilities, and

adjacent public facilities, aesthetic design elements play a significant role. Specifically, each increase in one of the eight aesthetic design variables resulted in a 6.2% increase in residential satisfaction when controlling for other factors. It was further observed that three specific aesthetic design variables – the main complex entrance design (4th), exterior mass design (7th), and landscape design (12th) – had a significant impact, accounting for 17.16% of the overall residential satisfaction in Seoul apartment complexes.

These findings contribute to the theoretical understanding of residential satisfaction and the consideration of aesthetic design elements in the development of apartment complexes. They advocate for a quantitative and practical approach, such as surveys of residential satisfaction, to accurately assess the impact of aesthetic design elements. From a practical standpoint, the results have important implications for suppliers involved in the design and construction of residential buildings. By recognizing the significant influence of aesthetic design elements, suppliers can effectively incorporate them into their designs to enhance resident experiences and satisfaction levels. Moreover, the study provides practical information for residents and customers in evaluating and selecting apartment complexes. By considering not only traditional factors like physical functions and regional features but also the role of aesthetic design elements in shaping residents' quality of life, customers can make informed choices for a more satisfying living environment.

Notations

Abbreviations

POE	post-occupancy evaluation
BQI	building quality index

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