



# *Prototyping for Better Living: A Design Thinking Framework to Enhance Education-Integration in Nursing Home Environments*

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## **A**bstract

*This study examines environmental factors influencing Education-Integration in nursing homes and their impact on residents' quality of life (QoL), with a focus on architectural design. Using a mixed methods approach including literature review, Delphi technique, and surveys of 384 randomly sampled elderly residents in Iran, the research identifies key spatial factors and proposes an adaptive design model. Structured around a Design Thinking framework, the process progresses from empathizing with residents' needs, defining core environmental factors via expert consensus, ideating architectural strategies, and prototyping design guidelines to testing the framework's impact on QoL through structural equation modeling (SEM-PLS). Pearson correlation and confirmatory factor analysis were conducted using SPSS 24 and Smart PLS. Results indicate that all seven identified factors significantly correlate with QoL, with "Joyfulness of Architectural Spaces", "Social Interactions and Community Spaces", and "Restorative Design" demonstrating the strongest associations. The findings validate the proposed Education-Integrated Design framework as a human-centered, evidence-based prototype for enhancing older adults' well-being through intentional spatial planning. This model offers architects and policymakers actionable guidelines for transforming nursing homes into dynamic, learning-oriented environments that actively support residents' physical, psychological, and social quality of life.*

## **K**eywords

*Design, Environment, Education-Integration, Nursing Home, Quality of Life.*

## Introduction

As predicted, the global population of older adults reached one billion in 2020, in industrialized countries, seniors make up an average of 16% of the population, and this percentage is projected to increase by up to 3% in the coming decades (Jadidi, Farahaninia, Janmohammadi, & Haghani, 2011). In Iran, studies and statistical indicators suggest a rapid growth in the aging population. It is estimated that by the year 2032 (corresponding to the early 2030s), approximately 25-30% of the population will be aged 50 or above (Jaghtaei, 2006; Ahangari, Kamali, & Arjomand Hesabi, 2007). However, contemporary seniors often experience a decline in their quality of life among their peers (Burke, 2014, Changizi, & Panahali, 2016). The search for influential factors affecting the quality of life is of great importance. Quality of life (QoL) is a multidimensional construct encompassing physical, psychological, social, and environmental well-being, rather than a mere demographic indicator like life expectancy. It is a critical and influential indicator within the social determinants of health (SDH), reflecting the cultural, social, economic, and health status of a community. The quality-of-life index has become a marker of disparities in health within various societies (Fereshtenejad et al., 2010).

In Iran, the topic of elderly quality of life has received considerable attention in numerous research studies; for instance, a research by Beyrami (2014) and et al. (1392 in the Persian calendar) in Iran found that elderly individuals living in nursing homes exhibit more signs of anxiety, depression, physical indications, and social dysfunction compared to those living in their own homes (Beyrami et al., 2014; Sharifi Daramadi & Panah Ali, 2011). It is essential to focus on enhancing the quality of life for elderly individuals, particularly those residing in care homes. While various disciplines such as psychology, sociology, medical sciences, and nursing have addressed the topic of older adults' quality of life from different perspectives, there is a lack of research in the field of architecture. Providing educational spaces for seniors is a crucial factor in improving their well-being, as research has shown that educated individuals have higher levels of health-related quality of life (HLE) (Crimmins & Saito, 2001; Montez & Hayward, 2014; Chiu et al, 2016).

Additionally, individuals with higher education levels tend to have a longer lifespan, particularly among those aged 65 and above, regardless of gender. Studies by Lièvre and colleagues (2008) have found that beyond the age of 70, individuals with lower education levels are expected to live approximately 6.11 years shorter than those with higher education levels, without experiencing cognitive disorders. More recent research has also shown that higher education levels not only improve quality of life but also reduce physical disability among those aged 65 and older; this has been demonstrated in a study conducted in 10 member countries of the European Union (EU) (Leterme & Testori, 2012). Furthermore, the implementation of a self-care educational program has been shown to significantly improve the quality of life among the elderly, as indicated by the research of Heidari and Shahbazi (2012). Additionally, a qualitative study conducted by Zarghami (2014) in the field of design suggests that the proximity of nursing homes to educational spaces can enhance the quality of life for the elderly (Zarghami & Olfat, 2014).

As previously mentioned, the proximity of nursing homes to educational spaces can have a significant positive impact on the quality of life for the elderly. Although statistics indicate improvements in medical, nursing, and psychological domains influenced by non-physical factors, the impact of the design of physical spaces in facilitating elderly education and enhancing their quality of life should not be overlooked. This study aims to investigate the factors related to the Education-Integration of physical space and its potential correlation with changes in the quality of life for the elderly, which is a subject of interest from both architectural and design perspectives. Identifying the influential factors in enhancing the Education-Integration of the physical environment within nursing homes can significantly contribute to improving both the quality of life and overall well-being of elderly residents.

In this study, Educational Integration in Physical Space refers to the architectural design approach that seamlessly embeds learning opportunities, skill development, and intergenerational knowledge exchange into the spatial layout of nursing homes.

To bridge the gap between architectural theory and practical geriatric design, this study adopts a Design Thinking research structure. Rather than implementing a full industrial Design Thinking cycle involving iterative physical prototyping, the study applies the core logic of human-centered problem framing to the architectural context of nursing homes. In this framework, the Empathize and Define phases were operationalized through resident surveys, literature synthesis, and Delphi-based expert validation. The Ideation phase involved the generation of spatial and architectural strategies through interdisciplinary synthesis and expert interpretation. The Prototype phase was represented through the development of a conceptual architectural guideline model (Table 7), functioning as a preliminary spatial prototype rather than a physical mock-up. Finally, the Test phase evaluated the conceptual framework statistically through Structural Equation Modeling (SEM-PLS) to examine its relationship with older adults' quality of life outcomes. This adapted application aligns with recent architectural and social-design studies that employ Design Thinking as a human-centered analytical framework rather than a strictly product-development protocol.

The theoretical foundation of this approach is rooted in contemporary interpretations of Design Thinking within interdisciplinary and human-centered research. Contemporary studies demonstrate that Design Thinking extends beyond a product-design methodology and is increasingly recognized as a human-centered approach for addressing complex social, educational, and environmental challenges. According to Tim Brown (2008), Design Thinking emphasizes a deep understanding of users' needs, creative ideation, and the development of innovative solutions.

Similarly, Nigel Cross (2011) describes Design Thinking as a way of understanding how designers translate human problems into practical and spatial solutions. Subsequent studies have further argued that this approach has been adaptively applied in interdisciplinary and non-industrial research contexts and is not necessarily limited to iterative physical prototyping (Johansson-Sköldberg et al., 2013). Moreover, Design Thinking has been shown to enhance innovation and decision-making processes by reducing cognitive biases and prioritizing users lived experiences and needs (Liedtka, 2015). In this regard, Razzouk and Shute (2012) also emphasize that Design Thinking is a flexible, analytical, and human-centered process that can be effectively employed in educational, architectural, and environmental research for the development of conceptual frameworks and design strategies.

## Literature Review

### 1. Education, Longevity, and Quality of Life

Extensive empirical research establishes educational attainment as a critical determinant of healthy aging and enhanced quality of life (QoL). Higher education levels are consistently associated with extended life expectancy, reduced mortality rates, and a lower prevalence of cognitive impairment (Fiske, Kaplan, Spittel, & Zeno, 2014; Kalediene & Petrauskienė, 2000; Kim & Kim, 2016; Manton, Stallard, & Corder, 1997; Sarah & James, 2014). Lièvre, Alley, and Crimmins (2008) demonstrated that beyond age 70, individuals with lower educational backgrounds experience significantly shorter lifespans free of cognitive decline. Similarly, Colet, Mayorga, and Amador (2010) found that university-educated elderly residents report better outcomes in pain management, reduced loneliness, and enhanced social perception.

Educational variables, when combined with physical activity and environmental modifications, have also been identified as pivotal in improving QoL for both elderly residents and caregivers (Ghezjeljeh et al., 2014). Successful lifelong learning initiatives across Europe, Latin America, and Japan further underscore the psychosocial and health benefits of structured educational programs (Nusberg, 1982). However, Tavares, Dias, and Munari (2012) caution that poorly contextualized group educational activities may inadvertently limit social participation and autonomy, highlighting the need for tailored implementation. Walberg's (1980) educational productivity model explicitly incorporates environmental design as a mediating variable, while Leterme and Testori (2012) emphasize the importance of continuous education

within adaptable, nature-integrated, and home-like settings. Despite these well-documented links, the architectural and spatial dimensions of educational integration in geriatric care remain underexplored.

## ***2. Spatial Design for Elderly Learning and Environmental Adaptability***

The translation of educational benefits into physical environments requires deliberate spatial design strategies that prioritize sensory engagement and experiential learning. Nováková and Giertlová (2016) highlight the value of learning outside traditional classrooms, demonstrating that horticultural activities, food preservation workshops, and environmental awareness programs foster practical engagement and cognitive stimulation.

Nakajo (2013) reinforces this by showing that open sensory environments featuring fragrant gardens, auditory cues from water and wind, and tactile soil interaction significantly improve cognitive and emotional well-being, particularly among individuals with dementia. The integration of diverse spatial typologies, including individual gardens, greenhouses, and art workshops, enables elderly residents to incorporate productive, skill-based activities into daily routines, thereby enhancing self-esteem and mitigating economic anxieties (Ahmadi et al., 2016).

Furthermore, Gilbert and Beal (1982) note that music and creative educational spaces resonate strongly with older adults, encouraging active participation through familiar cultural mediums. While Yasar and Kalfa (2015) examined social and educational incentives primarily within architectural education, their findings suggest that spatial configurations heavily influence learning motivation and environmental adaptability. These studies collectively indicate that physical spaces must be intentionally designed to support experiential, sensory, and self-directed learning; however, comprehensive architectural guidelines for geriatric educational integration remain fragmented.

## ***3. Social Interaction, Reminiscence, and Community-Driven Environments***

Beyond individual learning, the spatial organization of nursing homes profoundly influences social dynamics, intergenerational exchange, and psychological well-being. Roh et al. (2015) identify religion and social support as vital pathways for enhancing mental health and QoL, suggesting that design should accommodate spiritual gathering spaces and community rituals that foster a sense of belonging. Architectural configurations that promote visibility, accessibility, and flexible communal zones can transform passive care facilities into active learning communities.

Reminiscence-driven design, when supported by symbolic architectural elements, familiar materiality, and dedicated workshop or storytelling spaces, bridges past professional and personal experiences with present engagement, reinforcing cognitive continuity and emotional stability. Although the psychological and sociological benefits of socially and culturally integrated environments are well-documented, their systematic translation into actionable architectural parameters for elderly care facilities lacks empirical validation.

## ***4. Research Gap and Conceptual Framework Development***

While existing literature robustly connects education, environmental design, and social interaction with elderly QoL, a critical gap persists in the architectural domain. Most studies treat spatial design as a secondary variable or focus exclusively on medical, psychological, or sociological interventions. Few frameworks systematically integrate educational pedagogy with geriatric architectural planning. To address this gap, the present study synthesizes empirical findings and expert perspectives to develop a comprehensive conceptual model of Education-Integrated architectural spaces.

The initial factors derived from the literature (Table 1) were subsequently refined through a Delphi process with domain experts, ensuring that the final model prioritizes actionable, evidence-based design strategies tailored to the physical, cognitive, and social needs of elderly residents in nursing homes.

**Table 1:** Literature Review and Independent Variables Associated with Education-Integration of Architectural Space in Nursing Homes

Independent Variables Associated with the Education-Integration of Architectural Spaces	Factors	Potential Effects of Each Factor on Design from the Authors' Perspective
	<i>The concept of self-care education through design.</i> (Baraz et al., 2017) (Chan, 2015) (Quandt et al., 1994)	Designing gyms and exercise spaces for self-care education and the health of the elderly.
	<i>Cultural Identity through Design</i> (Koponen, 2017) (Kang & Kim, 2014) (Ghaderi, 2011)	Designing traditional, religious, and spiritual spaces to meet the emotional and spiritual needs of the elderly.
	<i>Spatial Capability in Educational Feedback</i> (Radcliff & Louise, 1991)	Designing exhibition spaces and sales areas for elderly artisans' handcrafted items.
	<i>Exploration of new experiences for the elderly through design</i> (Nakajo, 2013) (Ahmadi et al, 2016) (Kim & Kim, 2014) (Quandt et al, 1994)	Designing outdoor educational spaces. Designing open spaces for planting native plants.
	<i>The generative interaction of architectural spaces</i> (Cachioni et al, 2014) (Schuetz, 1980) (Blackman et al, 1976)	Designing educational spaces for gathering and discussion.
	<i>Updating the Elderly through Design facilities</i> (Escolar Chua et al, 2014) (Padilla-Góngora, 2017) (Naumanen & Tukiainen, 2010)	Designing workshop, classroom, and computer lab spaces is essential.
	<i>Self-Directed Educational Spaces</i> (Barker College, 2004)	Designing workshop, classroom, and computer lab spaces is essential, including the design of a classroom space that can accommodate both workshop activities and discussions.
	<i>Continuity of Education Through Design</i> (Weeks et al., 2016) (Cristina et al., 1996) (Karen, 1987) (Radcliff & Louise, 1991)	The space should be adaptable to engage with youth and promote intergenerational connections, such as integrating with kindergartens and library spaces.
	<i>Reminiscing Personal Experiences through Design</i> (Susan et al., 2013) (Rainbow et al., 2015) (Weiss et al., 1989) (Huhtinen-Hildén, 2014) (Chen et al., 2013)	Designing workshop spaces for teaching skills and offering hands-on artistic experiences. Conference room space for presenting and discussing professional and personal topics of interest and experiences among the elderly.
	<i>Enhancing Elderly Independence Through Design</i> (Weinstein, 1981) (Feingold et al., 1990) (Work, 1989) (Ann-Sofi et al., 2014)	Designing secure and independent spaces that are also controllable.
<i>Accessibility</i> (Evcil, 2010) (Verma & Huttunen, 2015) (Memken & Earley, 2007)	The potential for site access to other urban services or site accessibility within the senior care facility is an important consideration.	

## Methodology

In this study, a preliminary investigation of influential variables impacting learning in elderly health, architecture, nursing, and other relevant fields was conducted through extensive library research. A conceptual model was subsequently developed, detailing the crucial variables and key factors. To validate the identified variables, the Delphi technique was applied. Initially, a questionnaire based on the model was distributed to 15 experts for revisions or amendments, and 8 responded. Subsequently, the Content Validity Ratio (CVR) and Content Validity Index (CVI) were utilized to quantify the data. After redistributing the questionnaires to specialized individuals and refining the variables, the definitive factors were extracted. It is essential to mention that these factors were related to the independent variable (physical environmental learning). To assess the dependent variable, the standardized questionnaire on older people's quality of life (OPQOL-35) was employed. Finally, in order to examine the impact of the Education-Integrated Design of physical space on the quality of life of the elderly, the sample size was initially determined using Cochran's formula. Subsequently, the final questionnaires were distributed among 384 elderly residents in nursing homes through random sampling.

This research utilized statistical analyses conducted through SPSS 24, Smart PLS, and MCDM Engine software. The results were presented in two sections: descriptive findings and inferential findings. The descriptive findings section described the variables of the study population using frequency values, percentages, means, and standard deviations. Normality was assessed through skewness and kurtosis statistics, as well as the Shapiro-Wilk test.

Although the proposed environmental dimensions and quality-of-life indicators are conceptually qualitative and socially constructed in nature, they were operationalized as measurable latent constructs through a structured questionnaire using multi-item Likert-scale indicators. In environmental psychology, architectural research, and social sciences, latent qualitative concepts such as well-being, spatial perception, privacy, sociability, and environmental satisfaction are commonly quantified through psychometric measurement models and analyzed statistically using Structural Equation Modeling (SEM). Accordingly, the seven dimensions of Education-Integrated Design were treated as reflective latent variables measured through observable indicators derived from literature review, Delphi validation, and expert refinement.

To ensure methodological rigor, construct validity and reliability were assessed using Confirmatory Factor Analysis (CFA), factor loadings, Composite Reliability (CR), Average Variance Extracted (AVE), and discriminant validity measures, which are standard procedures in structural equation modeling and latent construct validation (Byrne, 2016; Hair et al., 2022; Kline, 2016). Therefore, the statistical analysis did not attempt to directly quantify abstract qualitative concepts themselves, but rather evaluated empirically measurable perceptions and experiences associated with those constructs, consistent with established approaches for modeling unobservable variables in social science and behavioral research (Fornell & Larcker, 1981; Kline, 2016).

The reliability of the research tools was evaluated using a combined reliability method and Cronbach's alpha. The questionnaire's validity was assessed through confirmatory factor analysis (CFA), factor loading indices, and mean variance extracted (AVE), which demonstrated satisfactory values. The inferential findings were determined through the use of Pearson correlation tests and Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) method. SEM-PLS was selected because it is widely recognized as an appropriate analytical method for examining relationships among latent and perceptual constructs in interdisciplinary social, behavioral, and environmental research. The method is specifically designed to analyze complex conceptual variables that cannot be measured directly but can be represented through multiple observed indicators.

A significance level of 0.05 ( $\alpha \geq 0.05$ ) was established for hypothesis testing. It should be noted that the variables were of an ordinal (rank) type, but due to their composite nature from multiple items, they were treated as interval-like variables (pseudo-interval) with some tolerance. In some cases, descriptive and inferential statistics for variables in the pseudo-interval level were utilized for analysis. When multiple ordinal variables are combined and a scale is constructed for an abstract concept, they can be considered as tolerance distance variables. This approach allows for the use of statistical and analytical methods, such as distance tests, in cases where the variables are at a distance level. This method can aid in explaining, modeling, and interpreting the data (Nayebi, 2009).

### **1. Adapted Use of Design Thinking Principles in Architectural Research**

The present study employs an adapted Design Thinking framework tailored to architectural and environmental gerontology research. Unlike conventional industrial Design Thinking processes that involve iterative physical prototyping and user-testing cycles, this research applies the conceptual principles of Design Thinking to organize a human-centered environmental investigation.

- **Empathize:** Elderly residents lived experiences, spatial preferences, and quality-of-life indicators were documented through surveys using the OPQOL-35 instrument.
- **Define:** Literature-derived variables were refined through Delphi expert evaluation, CVR/CVI analysis, and interdisciplinary synthesis to identify seven core environmental dimensions.

- **Ideate:** Architectural responses and environmental strategies were generated through iterative interpretation of empirical findings, architectural precedents, and expert recommendations. This phase focused on translating psychosocial needs into spatial interventions.
- **Prototype:** Instead of constructing physical prototypes, the study developed a conceptual architectural prototype in the form of structured design guidelines (Table 7). These guidelines represent scalable and transferable spatial planning principles for nursing home environments.
- **Test:** The proposed conceptual framework was evaluated quantitatively through Confirmatory Factor Analysis (CFA) and SEM-PLS to assess the statistical validity of relationships between the proposed environmental dimensions and elderly quality of life.

Accordingly, the study does not claim to implement a complete industrial Design Thinking cycle; rather, it adapts Design Thinking as a human-centered analytical and translational framework suitable for architectural research.

## 2. Sampling Procedure and Population

The target population for this study comprised all elderly residents (aged 60 years and older) living in nursing homes across Tehran. A multistage random sampling procedure was employed to ensure representativeness. First, considering the geographical and cultural diversity of Tehran, nursing homes were stratified by province. 22 districts representing different geographic locations (1 to 22) were randomly selected. Second, from each province, two nursing homes were randomly selected from the list of registered nursing homes provided by the State Welfare Organization of Iran. Third, within each selected nursing home, elderly residents were randomly sampled using a computer-generated random number sequence.

The inclusion criteria were: (1) age 60 years or older, (2) residing in the selected nursing home for at least six months prior to data collection, (3) absence of severe cognitive impairment (assessed by nursing home staff using the Mini-Mental State Examination, MMSE score  $\geq 18$ ), (4) ability to communicate verbally, and (5) provision of informed consent. Exclusion criteria were: (1) diagnosed with severe dementia or psychiatric disorders that prevented reliable questionnaire completion, (2) hearing or visual impairments that hindered communication, and (3) bedridden status. The required sample size was calculated using Cochran's formula for infinite populations:

$$n = \frac{Z^2 * p * (1-p)}{e^2}$$

where  $Z=1.96$  (95% confidence level),  $p=0.5$  (maximum variability), and  $e=0.05$  (margin of error). This calculation yielded a minimum required sample of 384 participants. To account for potential non-response or incomplete questionnaires, an additional 10% (38 participants) were sampled, resulting in 422 distributed questionnaires. After data cleaning, 384 valid questionnaires were retained (response rate = 91%).

The final sample consisted of 384 elderly residents (62% female, 38% male), with ages ranging from 60 to 94 years (Mean = 73.4, SD = 7.8). Participants' length of residence in nursing homes ranged from 6 months to 15 years (Mean = 4.2 years, SD = 3.1). Table 2 presents the detailed age distribution of the sample. While the findings are generalizable to elderly residents in Iranian nursing homes with similar demographic and health characteristics, caution is warranted when extrapolating to other cultural, national, or healthcare contexts.

Nevertheless, the stratified multistage random sampling procedure, combined with the adequate sample size determined by Cochran's formula, supports the internal validity and reasonable generalizability of the findings within the Iranian elderly nursing home population (Fowler, 2014; Levy & Lemeshow, 2013).

# Results

## 1. Descriptive Statistics

The demographic makeup of respondents is illustrated in the Figure below. Of the sample, 62% are elderly females, while 38% are elderly males.

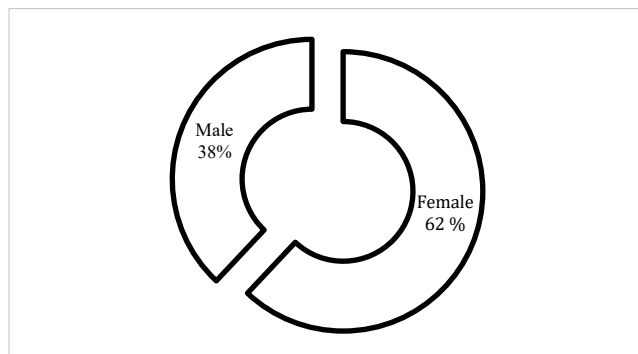


Figure 1: Pie Chart of Respondents' Gender Distribution (as a percentage)

Table 2 presents the distribution of participants' ages, categorized into three groups: 60 to 75 years old, 76 to 85 years old and over 85 years old. The majority or 57%, fall within the age range of 60 to 75 years. 37% are aged between 76 to 85 years, and only 6% are over 85 years old.

Table 2: Description of Respondents' Ages.

Age	Count	Percentage	Cumulative percentage
60 to 75 years old	220	57%	57%
76 to 85 years old	142	37%	94%
Over 85 years old	22	6%	100%
<b>Total</b>	<b>384</b>	<b>100</b>	

In Figure 2, the frequency distribution of educational levels is displayed. The distribution, from the highest to the lowest frequency, is as follows: Diploma holders make up 45%, Bachelor's degree and higher represent 16%, less than a high school diploma account for 16%, postgraduate diploma holders represent 12%, and individuals with no formal education comprise 11%.

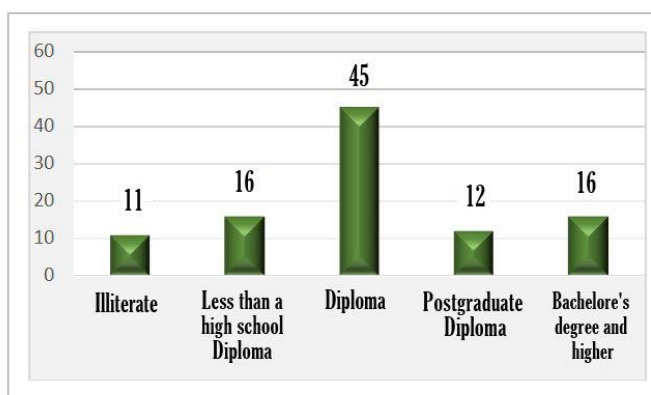


Figure 2: Column Chart of Respondents' Education Levels (as a Percentage)

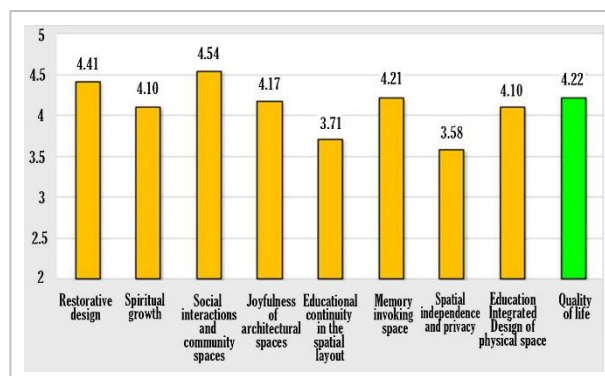
## 2. Description of the main variables

After presenting the Education-Integration factors in Table 1 to eight experts in the form of an open-ended questionnaire to suggest additional or reduced factors, this categorization underwent modifications, resulting in seven main factors that describe the Education-Integration Variable. Restorative design, Spiritual growth, social interactions and community spaces, Joyfulness of architectural spaces, educational continuity in spatial layout, Memory-invoking space, Spatial independence and privacy, Education Integrated Design of physical space. The primary variables were reclassified and are subsequently described in the table below after the questionnaires were sampled and distributed. The table below provides an overview of the primary variables, with mean, standard deviation, and minimum and maximum values used to describe them. The range of means is between 1 and 5 (indicating very low to very high). A bar chart following the table depicts the mean values of the primary variables.

**Table 3:** Descriptive Statistics for Primary Variables

Variables	Mean	Standard Deviation	Minimum	Maximum
<b>Restorative Design</b>	4.41	0.46	3	5
<b>Spiritual growth</b>	4.10	0.49	2.50	5
<b>Social interactions and community spaces</b>	4.54	0.57	2.75	5
<b>Joyfulness of architectural spaces</b>	4.17	0.54	2.50	5
<b>Educational continuity in the spatial layout</b>	3.71	0.52	2.50	5
<b>Memory invoking space</b>	4.21	0.58	2.67	5
<b>Spatial independence and privacy</b>	3.58	0.53	2.50	5
<b>Dependent variable: Education-Integrated Design of physical space</b>	4.10	0.41	3	5
<b>Quality of life</b>	4.22	0.25	3.56	5

The examination of means demonstrates that the mean of all variables is higher than the average score of 3, indicating that the elderly participants rated higher than average across all principal variables. The investigation of means reveals that the mean of Education-Integrated Design of physical space is 4.10, and the mean of Quality of Life is 4.22, suggesting both principal variables have significantly high values, highlighting their significant importance. Comparing the means of the components of Education-Integrated Design of physical space shows that the highest means belong to Social Interactions and Community Spaces with a value of 4.54, followed by Restorative Design with a mean of 4.41. The lowest mean corresponds to Spatial Independence and Privacy, registering at 3.58. Figure 3 presents a column chart of the mean values of the principal variables.



**Figure 3:** Column Chart of Variable Means

### 3. Normality of Variables

To assess the distribution of the data, statistical tests such as the Kolmogorov-Smirnov test and measures of skewness and kurtosis were employed. The findings are presented in Table 4. The significance of evaluating the normality of data distribution lies in that certain statistical methods such as Pearson correlation, t-tests, and analysis of variance rely on the assumption of data normality within the population. Additionally, estimating population parameters is contingent upon the assumption of variable distribution normality within the population. Statistical tests for assessing normality include the Kolmogorov-Smirnov test and Shapiro-Wilk test. If the obtained significance level for each variable exceeds 0.05, it can be concluded that the variable's distribution is normal, indicating no impediment for employing parametric tests. Regarding skewness and kurtosis, values between -2 and +2 indicate the univariate distribution's normality (George & Mallery, 2010).

**Table 4:** Skewness and Kurtosis Values and the Kolmogorov-Smirnov Test for Evaluating Normality of Primary Variables

Variables	Variable Kolmogorov-Smirnov	Skewness	Kurtosis
Restorative design	0.058	0.914	1.230
Spiritual growth	0.134	0.851	0.007
Social interactions and community spaces	0.095	0.833	0.696
Joyfulness of architectural spaces	0.088	0.526	1.312
Educational continuity in the spatial layout	0.142	0.512	0.455
Memory invoking space	0.139	0.615	0.230
Spatial independence and privacy	0.174	0.395	-0.045
Dependent variable: Education-Integrated Design of physical space	0.107	0.708	0.675
Quality of life	0.112	0.607	-0.790

The findings of the Kolmogorov-Smirnov test reveal that all research variables adhere to a normal distribution. The significance level derived from the test for all research variables exceeds 0.05 ( $0.05 < p$ ), indicating the normality of these variables. Moreover, the examination of skewness and kurtosis values indicates that all variables' skewness and kurtosis values fall within the range of -2 to +2, suggesting that all variables exhibit a normal or nearly normal distribution. In conclusion, based on the results of the Kolmogorov-Smirnov tests and the analysis of skewness and kurtosis values, it can be inferred that the distribution of all variables can be considered as normal or nearly normal, thus permitting the employment of parametric tests, such as Pearson correlation.

### 4. Inferential Findings

The relationships among variables were examined using Confirmatory Factor Analysis (CFA), correlation analysis, and Structural Equation Modeling (SEM). Prior to correlation analysis, linearity was verified using scatter plots (Figure 4). The linear and positive trend between Educational Integration and Quality of Life justified the use of Pearson's correlation and SEM. Figure 4 visually confirms a direct, positive association, indicating that enhanced spatial integration corresponds to improved resident well-being. Given the established normality of the data, Pearson's correlation was appropriately applied, with results detailed in Table 5. The correlation matrix demonstrates that all relationships between the Education-Integrated Design components and Quality of Life are statistically significant ( $p < 0.001$ ). The overall Education-Integrated Design construct exhibits a strong positive correlation with Quality of Life ( $r = 0.83$ ,  $R^2 = 0.69$ ), confirming that spatial integration directly enhances old adults' well-being. Among the individual factors, social

interactions and community spaces ( $r = 0.86$ ), Joyfulness of architectural spaces ( $r = 0.85$ ), and Restorative design ( $r = 0.78$ ) show the strongest associations with Quality of Life, highlighting their critical role in geriatric environmental design.

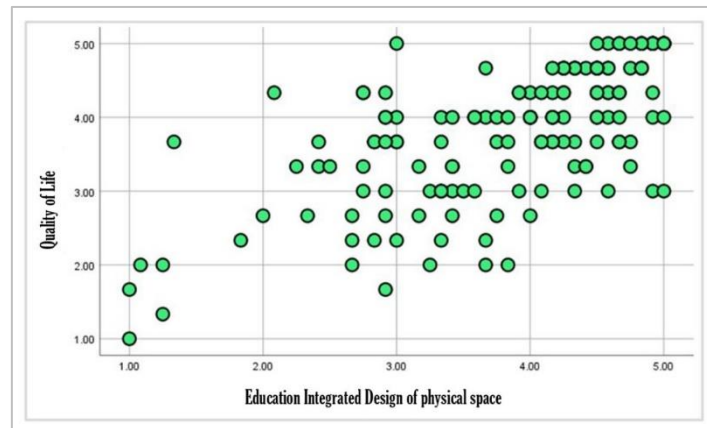


Figure 4: Scatterplot Matrix between Education-Integration and Quality of Life

The relationships between the variables were tested using Pearson's correlation test. As the result of the normality test indicated that the distribution of variables is normal, the Pearson's correlation test was employed. The correlation results are presented in Table 4.

Table 5: Correlation Test between Education-Integrated Components and Quality of Life

Variables	Correlation coefficient ( $r$ )	Coefficient of determination ( $R^2$ )	Significance level ( $P$ )
Restorative design	0.78	0.61	< 0.001
Spiritual growth	0.58	0.34	< 0.001
Social interactions and community spaces	0.86	0.74	< 0.001
Joyfulness of architectural spaces	0.85	0.72	< 0.001
Educational continuity in the spatial layout	0.62	0.38	< 0.001
Memory invoking space	0.64	0.41	< 0.001
Spatial independence and privacy	0.73	0.53	< 0.001
Education Integrated Design of physical space	0.83	0.69	< 0.001

In Table 5, the results of the correlation analysis between Education-Integrated Design of physical space and its components with Quality of Life are presented. The findings indicate that all relationships in the table are statistically significant, demonstrating a meaningful association between Education-Integrated Design of physical space and all its components with the variable of Quality of Life ( $p < 0.05$ ). The strength of correlation between Education-Integrated Design of physical space and Quality of Life is 0.83, indicating a strong relationship between these two variables. The positive direction of the relationship suggests that an increase in Education-Integrated Design of physical space is associated with an increase in Quality of Life. Analyzing the strength of correlation among the components of Education-Integrated Design of physical space reveals that the components "Social interactions and community spaces" with a coefficient of 0.86, "Joyfulness of architectural spaces" with a coefficient of 0.85, and "Restorative design" with a coefficient of 0.78 have the strongest relationships with Quality of Life.

Using the Smart PLS software, the validity of the questionnaire was assessed through measures of factor loadings and convergent validity. The reliability of the variables was evaluated using composite reliability and Cronbach's alpha tests. Factor loadings were determined by calculating the correlation value of indicators within a construct. If this value equaled or exceeded 0.40, it indicated that the variance between constructs and their indicators was greater than the variance due to measurement error, suggesting acceptable model measurement validity (Davari & Rezazadeh, 2013). A minimum threshold of 0.40 was established for factor loadings in this study. In addition to Cronbach's alpha, the composite reliability method was employed to assess reliability. Unlike Cronbach's alpha, composite reliability calculates the reliability of constructs based on their correlation with each other. A composite reliability value higher than 0.70 indicates sufficient internal stability for measurement models (Karimi, 2016).

Cronbach's alpha is a measure of internal consistency reliability, similar to factor analysis, which is used to evaluate the strength of correlations among items. Generally, the Cronbach's alpha value for a scale should be at least 0.70. The Average Variance Extracted (AVE) indicator was used to test convergent validity. Typically, AVE gauges the amount of variance that a latent variable captures from its indicators. Convergent validity ensures that the indicators of constructs should contribute a significant amount of variance to the overall construct. The AVE score ranges from 0 to 1, with higher values indicate better convergent validity. Following this, the measurement models are presented either in factor loadings or standard coefficient form. To assess the validity of the Education-Integrated Design of physical space scale, a second-order confirmatory factor analysis was employed because this variable consisted of multiple components. However, a first-order confirmatory factor analysis was used for assessing the Quality of Life.

### 5. Investigating the validity and reliability of Education Integrated Design of physical space

The validity and reliability of the Education Integrated Design of physical space were assessed through confirmatory second-order factor analysis. The scale comprises seven components and a total of 27 items. The measurement model is depicted in Figure 5, displaying standard coefficients, and Figure 6 shows the significance level. The results, including composite reliability, Cronbach's alpha, and extracted Average Variance Extracted (AVE), are presented in Table 6. The findings indicate that all items have validity, with factor loadings exceeding 0.40 and a significance level below 0.05 ( $p < 0.05$ ), and all t-values exceeding 1.96. Furthermore, all items in the Education Integrated Design of physical space exhibit factor loadings higher than 0.40, confirming the validity of all questions. The composite reliability ranges from 0.84 for the Social Interactions and Community Spaces component to 0.95 for Spiritual Growth, all exceeding the threshold of 0.70. The reliability scores of the scale and its components are statistically significant, and all components have Cronbach's alpha values exceeding 0.70, confirming their internal consistency reliability of the scale.

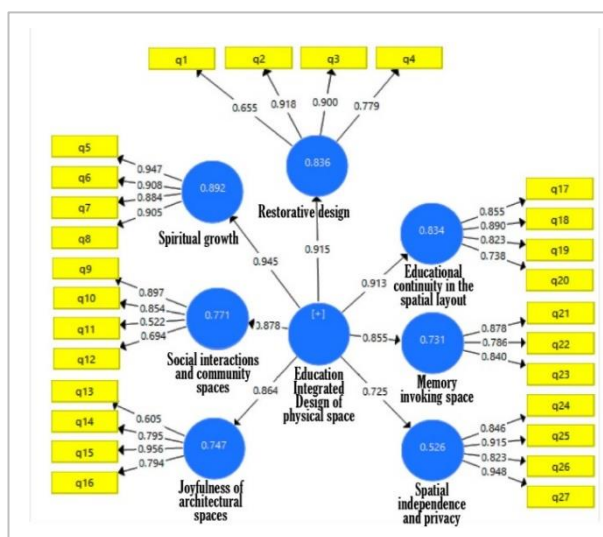


Figure 5: Measurement Model of Education Integrated Design of Physical Environment in Standard Coefficients (Factor Loadings)

The average variance extracted, indicating convergent validity, ranges from 0.57 for the Social Interactions and Community Spaces component to 0.83 for Spiritual Growth, all exceeding the desired threshold of 0.50. In conclusion, the results confirm the validity and reliability of all components within the Education Integrated Design of physical space and its corresponding questions.

Figure 5 illustrates the standardized coefficients or factor loadings of the Education Integrated Design of Physical Environment measurement model. As shown in the figure, all factor loadings have appropriate and confirmed values, all of which are above 0.40.

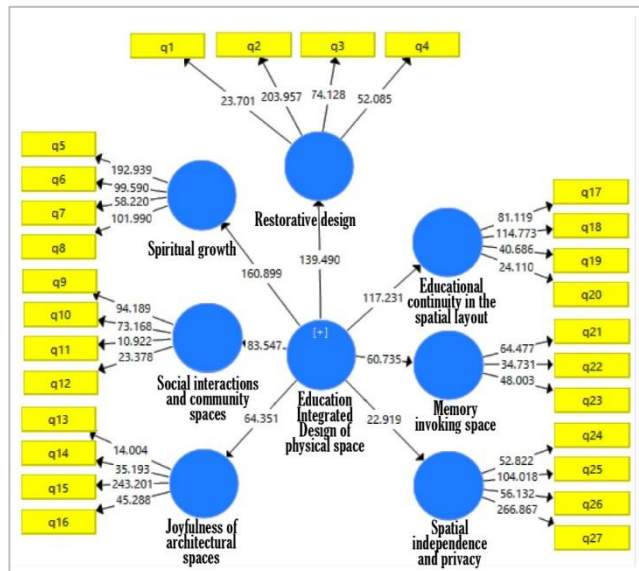


Figure 6: The measurement model of Education Integrated Design of Physical Environment in terms of t-values (significance)

The measurement model for the Education Integrated Design of Physical Environment is represented in terms of t-values (significance). As shown in the figure, all t-values for the factor loadings are greater than 1.96, indicating that there is a significant relationship between the items and constructs with at least 95% confidence ( $p < 0.05$ ).

Table 6: Confirmatory Factor Analysis (CFA) results, evaluating the validity and reliability of the Education Integrated Design of Physical Environment

Factor	Item Number	Standardized Loading (Factor Loading)	Average Variance Extracted (AVE)	Composite Reliability	Cronbach's Alpha
Restorative design	1	0.66	0.67	0.89	0.83
	2	0.92			
	3	0.90			
	4	0.78			
Spiritual growth	5	0.95	0.83	0.95	0.93
	6	0.91			
	7	0.88			
	8	0.91			

<b>Social interactions and community spaces</b>	9	0.90	0.57	0.84	0.74
	10	0.85			
	11	0.52			
	12	0.69			
<b>Joyfulness of architectural spaces</b>	13	0.60	0.64	0.87	0.80
	14	0.80			
	15	0.96			
	16	0.79			
<b>Educational continuity in the spatial layout</b>	17	0.86	0.69	0.90	0.85
	18	0.89			
	19	0.82			
	20	0.74			
<b>Memory invoking space</b>	21	0.88	0.70	0.87	0.78
	22	0.79			
	23	0.84			
<b>Spatial independence and privacy</b>	24	0.85	0.78	0.93	0.91
	25	0.92			
	26	0.82			
	27	0.95			

**Note:** All factor loadings are statistically significant at a confidence level of 95%: ( $p < 0.05$ ) and ( $t > 1.96$ )

## Discussion

### 1. From Correlational Findings to Design Hypotheses: The Need for Prototyping and Empirical Testing

Before presenting the architectural design features associated with each of the seven environmental factors, a critical methodological clarification is necessary. The statistical analyses reported in Section 4 (Pearson correlations, SEM-PLS) establish associations between perceived environmental factors and self-reported quality of life among elderly residents. These findings are correlational, not causal. They demonstrate that elderly residents who perceive higher levels of restorative design, social interaction spaces, and joyful architectural features in their current nursing homes also report higher quality of life. However, this correlational evidence does not demonstrate that implementing the design guidelines proposed in Table 7 would cause improvements in quality of life. According to the Design Thinking process and consistent with evidence-based design principles in architecture claims about the *effectiveness* of specific design interventions require at least three additional stages of inquiry (Brown, 2008; Zeisel, 2006):

- **Prototyping:** Translating design guidelines into tangible architectural prototypes (e.g., scale models, digital simulations, virtual reality environments, or real-world mock-up spaces).
- **User testing:** Exposing elderly residents to these prototypes and systematically gathering feedback on usability, preference, comfort, and perceived well-being.

- **Post-occupancy evaluation (POE):** Implementing the design in actual nursing home environments and conducting longitudinal studies to measure changes in quality of life before and after intervention, ideally with control groups.

The present study has not undertaken any of these three stages. Therefore, the design features presented in [Table 7](#) should be interpreted as evidence-informed design hypotheses rather than validated design solutions. They are derived from: (a) statistical correlations identified in this study, (b) the existing literature reviewed in Section 2, and (c) expert input from the Delphi process. These hypotheses require rigorous testing through prototyping and empirical evaluation before architects or policymakers can claim confidence in their effectiveness. With this important caveat established, the following subsections interpret each of the seven factors through an architectural lens and propose spatial strategies that *may* support education-integrated environments, pending future validation. The empirical analysis confirms that all seven spatial factors significantly correlate with residents' quality of life, collectively validating the Education-Integrated Design framework. Rather than reiterating statistical coefficients, this section interprets each factor through an architectural lens, links it to actionable spatial strategies ([Table 7](#)), and outlines its direct impact on elderly well-being.

## 2. Education-Integrated Restorative Architecture: A Multi-Dimensional Framework for Enhancing Health, Well-being, and Quality of Life in Nursing Home Environments

*Restorative design* emerges as a foundational environmental mediator for health-related self-care education. Based on the correlational evidence, it is hypothesized that integrating rehabilitation zones, hydrotherapy facilities, and sensory-engaging landscapes may support health-related self-care education. These spatial strategies, presented as evidence-informed hypotheses in guidelines 1–4 of [Table 7](#), are suggested to potentially foster bodily autonomy and reduce dependency anxiety. However, these hypothesized outcomes require empirical validation through prototyping and post-occupancy evaluation, which collectively elevate their perceived quality of life ([Choobdari et al., 2015](#); [Gonzalez & Kirkevold, 2015](#); [Elias & Cook, 2016](#)).

*Spiritual growth* is architecturally expressed through culturally resonant, contemplative spaces that support cognitive continuity and emotional stability. Designing intimate prayer alcoves, ceremonial gathering halls, and spiritually symbolic circulation paths fosters an environment where mental well-being is nurtured alongside religious or existential reflection. These principles align with guidelines 5–8 in [Table 7](#), which emphasize adaptable spiritual zones and community-oriented charitable exhibitions. By anchoring residents in familiar cultural and faith-based spatial narratives, design mitigates existential distress and reinforces psychological resilience ([Roh et al., 2015](#); [Sattarifard, 2015](#)).

*Social interactions and community spaces* require spatial configurations that deliberately dissolve barriers between personal and communal zones. Modular assembly halls, transitional lounges, and semi-outdoor pergolas encourage peer-to-peer knowledge exchange and intergenerational dialogue, effectively turning the facility into an active learning ecosystem. Guideline implementations 9–13 in [Table 7](#) demonstrate how accessible intersections and neighborhood-integrated educational hubs stimulate sustained social participation. Correlational evidence suggests that spatial configurations promoting accessibility and visibility are associated with higher levels of social engagement. It is hypothesized but not yet empirically demonstrated that the design strategies outlined in guidelines 9–13 ([Table 7](#)) may counteract social isolation and support health-related quality of life. ([Chiao et al., 2013](#); [Gonzalez & Kirkevold, 2015](#); [Elias & Cook, 2016](#); [Gharebeglou, Farshchian & Mohamadalian, 2015](#)). Causal claims await future prototyping and longitudinal testing.

*Joyfulness of architectural spaces* hinges on multi-sensory, adaptable environments that invite playful cognition and creative exploration. Through dedicated music and poetry halls, safe tactile gardens, and reconfigurable furniture layouts, spatial design can transform routine care into engaging experiential learning. These strategies correspond to guidelines 14–20 in [Table 7](#), which prioritize flexible programming and sensory stimulation. By fostering environments that trigger positive affect and mental agility,

architectural joyfulness directly reduces depressive symptoms and enhances overall life satisfaction (Sheybani Tazraji & Pakdaman, 2010).

*Educational continuity in spatial layout* demands porous planning that physically and programmatically connects nursing homes with external educational and community networks. Integrating digital learning labs, bi-directional teaching workshops, and intergenerational childcare zones ensures that residents remain active contributors rather than passive recipients of care. Guidelines 21–25 in Table 7 outline how shared gardens, exhibition corridors, and community-accessible service hubs sustain this continuity. This spatial integration preserves purposeful daily routines and reinforces cognitive engagement, directly supporting sustained quality of life in later years (Swindell & Mayhew, 2006).

*Memory-invoking spaces* utilize biographical environmental cues to trigger reminiscence and skill revival, transforming physical settings into therapeutic archives of personal history. Nostalgic material palettes, dedicated storytelling rooms, and traditional craft workshops provide tactile and visual anchors that reconnect residents with their professional and cultural identities. These interventions align with guidelines 26–29 in Table 7, which advocate for customizable aesthetic controls and heritage-responsive programming. By validating past experiences through spatial design, facilities strengthen cognitive anchoring and emotional security, thereby improving psychological well-being (Mohammadzadeh, Dolatshahy & Mohammadkhani, 2011).

*Spatial independence and privacy* must balance safety protocols with territorial autonomy through deliberate visibility control and adaptable personal boundaries. Designing controllable circulation paths, private activity nooks, and accessibility-compliant educational zones empowers residents to manage their environment without excessive institutional oversight. Guidelines 30–34 in Table 7 operationalize this balance through adjustable spatial partitions, mobility-tailored layouts, and resident-led environmental modifications. This architectural respect for autonomy directly enhances dignity and self-determination, which are critical determinants of perceived quality of life (Bengtsson et al., 2015).

Collectively, these seven spatial dimensions demonstrate that Education-Integrated Design is not merely a programmatic addition but a foundational architectural strategy. By translating empirical findings into the actionable spatial parameters detailed in Table 7, this framework provides architects and policymakers with a replicable, evidence-based model for transforming nursing homes into dynamic, learning-oriented environments that actively sustain elderly quality of life.

**Table 7: Evidence-Informed Design Hypotheses for Education-Integrated Nursing Home Environments (Require Prototyping and Empirical Validation)<sup>1</sup>**

Environmental components of the Education-Integrated space		
Education-Integration Design Factor	Factor definition	Design Solutions
<i>Restorative design</i>	Designing spaces related to the education of physical health and safety for the elderly.	<ul style="list-style-type: none"> <li>▪ Planning for the placement of educational facilities near care facilities.</li> <li>▪ Incorporating spaces for rehabilitation and physiotherapy, including hydrotherapy pools and art therapy.</li> <li>▪ Creating classroom spaces to provide self-care guidance. Designing halls for group-oriented light exercises, either indoors or incorporating natural elements.</li> <li>▪ Including aroma therapy spaces and beneficial healing plant areas for the well-being of the elderly.</li> </ul>

<sup>1</sup> The design strategies presented in this table are derived from correlational findings, literature synthesis, and expert consensus. They represent hypotheses about spatial features that may support education-integrated environments and elderly quality of life. None of these strategies have been prototyped, implemented, or empirically tested with target users. Future research must undertake participatory design, prototyping, and post-occupancy evaluation before any claims of effectiveness can be made.

<p><i>Spiritual growth</i></p>	<p>Designing education-integrated spaces to promote the mental well-being of the elderly.</p>	<ul style="list-style-type: none"> <li>▪ Designing religious and spiritual spaces for the purpose of conducting ceremonies and engaging in religious discussions.</li> <li>▪ Facilitating the participation of the elderly in religious spaces by modifying activities or spiritual arrangements.</li> <li>▪ Designing small, intimate personal worship spaces.</li> <li>▪ Organizing workshops and exhibitions showcasing the talents of the elderly, with the aim of providing humanitarian and charitable assistance</li> </ul>
<p><i>Social interactions and community spaces</i></p>	<p>Designing spaces that promote personal connections, increase awareness, and facilitate information sharing.</p>	<ul style="list-style-type: none"> <li>▪ Developing environments that promote education and dialogue, such as versatile assembly halls with modifiable layouts.</li> <li>▪ Creating intermediary social spaces for seniors, including lounges, to encourage intergenerational communication.</li> <li>▪ Dedicating area for communal activities, such as gardening, room decoration, and building upkeep.</li> <li>▪ Positioning educational facilities within residential neighborhoods for convenient access to recreational resources.</li> <li>▪ Incorporating cozy and inviting outdoor spaces that encourage socializing and interaction.</li> </ul>
<p><i>Joyfulness of architectural spaces</i></p>	<p>Design focused on engaging the elderly through group activities and intellectual games.</p>	<ul style="list-style-type: none"> <li>▪ Undertaking the design of a music room for both practice and performances, as well as a hall for poetry recitals and storytelling.</li> <li>▪ Creating individual greenhouse spaces for planting and gardening purposes.</li> <li>▪ Designing gardens and safe natural areas to facilitate sensory experiences, including touch, smell, hearing, and other sensations.</li> <li>▪ Designing recreational spaces aimed at reviving past lost skills, such as painting, art therapy, and similar activities.</li> <li>▪ Designing recreational spaces to maintain the mental well-being of the elderly, including Sudoku, card games, and creative activities.</li> <li>▪ Implementing flexible and adaptable furniture arrangement and classroom segmentation.</li> <li>▪ Ensuring accessibility of outdoor spaces for mental well-being.</li> </ul>
<p><i>Educational continuity in the spatial layout</i></p>	<p>The formation of an educational plan that aligns with the use of nursing homes as art exhibition spaces to convey experiences.</p>	<ul style="list-style-type: none"> <li>▪ Developing an educational plan that aligns with senior living centers and provides both internal and external services to elderly residents.</li> <li>▪ Designing digital and computerized spaces and rooms to keep the elderly informed and engaged.</li> <li>▪ Creating safe gardens and natural environments that cater to sensory experiences such as touch, smell, hearing, and other sensations.</li> <li>▪ Designing bi-directional educational spaces that can teach technical experiences and workshops to youth.</li> <li>▪ Integrating the senior living center's space and site with children's areas for care and education, facilitated by the elderly, fostering</li> </ul>
<p><i>Memory invoking space</i></p>	<p>Symbols, design elements, and specific activities can evoke the past for an individual, leading to personal discoveries</p>	<ul style="list-style-type: none"> <li>▪ Incorporating nostalgic colors, textures, and design symbols in educational spaces for the elderly to evoke memories and promote adaptability.</li> <li>▪ Designing storytelling rooms for intergenerational storytelling, creating a space for the elderly to share their memories and for children and teenagers to engage in storytelling.</li> <li>▪ Establishing dedicated spaces for elderly individuals to engage in artistic activities they enjoyed in the past, such as painting, sculpture, sewing, and more.</li> <li>▪ Elderly individuals should have the freedom to choose colors, decorations, layouts, and educational spaces that align with their traditional perspective and shared past.</li> </ul>

## Conclusion

The primary objective of the present study was to investigate the *correlational relationship* between perceived elements of Education-Integrated Design of physical space in nursing homes and self-reported Quality of Life (QoL) among elderly residents. Based on the statistical evidence presented in Section 4, the following conclusions are drawn.

A total of seven environmental factors were identified through literature review and Delphi expert validation. Confirmatory factor analysis (CFA) established the reliability and validity of the seven-factor measurement model (Table 6; all factor loadings > 0.40, composite reliability > 0.70, AVE > 0.50). Using Pearson correlation analysis (Table 5), all seven factors demonstrated statistically significant positive correlations with QoL ( $p < 0.001$ ). The overall Education-Integrated Design construct showed a strong positive correlation with QoL ( $r = 0.83$ , 95% CI [0.79, 0.87],  $R^2 = 0.69$ ). The strongest individual correlations were observed for "Social interactions and community spaces" ( $r = 0.86$ ), "Joyfulness of architectural spaces" ( $r = 0.85$ ), and "Restorative design" ( $r = 0.78$ ). The weakest but still significant correlation was observed for "Spatial independence and privacy" ( $r = 0.73$ ).

It is critical to emphasize that these findings demonstrate *associations* between perceived environmental factors and self-reported QoL, not causal relationships. The cross-sectional design of this study cannot establish whether: (a) education-integrated design improves QoL, (b) higher QoL leads to more positive perceptions of the environment, or (c) unmeasured third variables (e.g., general health status, social support, personality factors) account for the observed correlations. Therefore, statements implying causality—such as "*changes in QoL*" or "*improving QoL through design*"—are not supported by the evidence presented. The correct interpretation is that elderly residents who perceive higher levels of education-integrated design features in their nursing homes also report higher levels of QoL.

Contrary to the original manuscript's claim, this study did not employ a "*validated Design Thinking workflow*." Rather, the study drew *heuristic inspiration* from Design Thinking as an organizing framework for human-centered problem framing. The five phases (Empathize, Define, Ideate, Prototype, Test) were used retrospectively and conceptually to structure the research process, not as an empirically validated methodology. The "*Prototype*" in this study refers to a conceptual architectural guideline model (Table 7), not a physical or digital prototype that was tested with users. The "*Test*" phase refers to statistical validation of correlational relationships, not empirical testing of design interventions. Any claim that this study offers a "*validated*" methodology is inaccurate and has been removed.

The architectural design features proposed in Table 7 represent *evidence-informed design hypotheses* derived from correlational findings, literature synthesis, and expert input. None of these design strategies have been prototyped, implemented, or empirically evaluated with elderly residents or caregivers. Therefore, no claims about their effectiveness in improving quality of life can be made. Future research must translate these hypotheses into tangible prototypes (e.g., scale models, virtual reality environments, or real-world mock-ups), conduct user testing with elderly participants, and undertake longitudinal post-occupancy evaluations to assess whether implementation of these design features causally affects quality of life outcomes.

One important limitation of this study concerns the adapted use of the Design Thinking framework. While the research incorporated the human-centered logic and sequential structure of Design Thinking, it did not include iterative physical prototyping or real-time user-based testing commonly associated with professional product-design applications. Therefore, the Ideation, Prototype, and Test phases should be interpreted as conceptual and analytical architectural processes rather than full experimental design iterations. The most significant limitation of this study is that none of the architectural design features proposed in Table 7 have been prototyped, constructed, or empirically evaluated with elderly residents. Future studies may strengthen this framework through immersive simulation environments, participatory co-design workshops, virtual reality prototyping, and post-occupancy evaluations involving elderly

residents and caregivers. Any claim of effectiveness would require: (a) translation of design hypotheses into tangible architectural prototypes (e.g., scale models, VR environments, or mock-up spaces), (b) systematic user testing with elderly residents and caregivers, (c) iterative design refinement based on user feedback, (d) implementation in real-world nursing home settings, and (e) longitudinal post-occupancy evaluation with control groups or pre-post comparison designs (Zeisel, 2006; Preiser et al., 2018). The statistical findings reported in this study are correlational, demonstrating associations between perceived environmental factors and reported quality of life. These findings do not constitute evidence that implementing the proposed design guidelines would cause improvements in quality of life. Therefore, the design guidelines presented here should be interpreted as evidence-informed hypotheses for future research, not as validated design solutions, and architects and policymakers are cautioned against implementing these guidelines as proven interventions; rather, they should view them as a starting point for participatory design processes and empirical testing.

Ultimately, the Education-Integrated Design framework developed in this study functions as a prototype model for architects, gerontologists, and healthcare policymakers. The present study contributes a validated measurement instrument (seven-factor model of Education-Integrated Design) and evidence of positive correlations between perceived environmental factors and old adults' QoL in Iranian nursing homes. While the current validation is grounded in the Iranian nursing home environment, and the framework's modular structure enables cross-national scaling and contextual customization, the study does not provide evidence for causal effectiveness of design interventions, does not employ a validated Design Thinking methodology, and does not offer proven design solutions. Therefore, the proposed design guidelines (Table 7) should be interpreted as hypotheses for future research rather than prescriptions for practice. By structuring environmental interventions through a Design Thinking-informed workflow, the model offers a human-centered methodology that can be adapted, tested, and refined across diverse cultural and architectural contexts. Architects and policymakers are encouraged to treat these findings as a starting point for participatory, evidence-based design processes, and future research involving international stakeholder panels will be required to further enhance the framework's global applicability. Nevertheless, the present framework already provides a structured, evidence-informed foundation for exploring how institutional care facilities may be transformed into more dynamic, learning-oriented environments that support elderly well-being.

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