New Design Ideas
Vol.8, No.1, 2024, pp.137-168
https://doi.org/10.62476/ndi81137

ENHANCING USER EXPERIENCE IN INTERIOR ARCHITECTURE THROUGH BIOPHILIC DESIGN: A CASE STUDY OF URBAN RESIDENTIAL SPACES

Masoumeh Khanzadeh*

Nuh Naci Yazgan University, Kayseri, Türkiye

Abstract. This study aims to investigate how applying biophilic design principles to interior architecture—especially in urban residential contexts—can improve the user experience while accounting for the influence of different user profiles. It has been demonstrated that using natural components and patterns in constructed settings has a good influence on people's health and sense of connection to the natural world. The impact of numerous biophilic design elements on occupant well-being, productivity, and emotional connection to their living environments will be thoroughly examined. These include natural light, vegetation, water features and natural materials. University faculty and their families are the sole residents of Kayseri Nuh Naci Yazgan University Faculty Residences in Turkey a unique urban living community. Located at the corner of the university, this space offers individualized accommodation alternatives, creates a close-knit community and provides a distinctive living environment that meets faculty members' academic needs by guaranteeing easy access to educational resources. 54 residential units are participating in the study. Respondents are academic staff members that reside and work in the residences of Nuh Naci Yazgan University. The study centers on their housing experiences and they are its primary subjects. Both qualitative and quantitative data were gathered using a combination of in-depth observations, questionnaires and interviews in addition to random sampling. The study closes a crucial knowledge gap regarding the application of biophilic design in urban settings, given the current state of growing urbanization. This study is significant because it may help design more environmentally friendly and psychologically stimulating urban living environments. The results of this study can help architects, designers and urban planners create healthier and more user-centered urban places, which will ultimately improve the quality of life in urban settings, by examining how biophilic design affects user experiences. Using a case study methodology, the study was focused on NNYU Residences as a particular urban living environments as its study subjects. Observations, surveys and interviews was used to gather both qualitative and quantitative data to investigate users' opinions about the integration of biophilic design elements in their surroundings. This study has multiple main objectives. It seeks to comprehend how consumers interpret biophilic design elements, evaluate how the design affects inhabitants' well-being, investigate sustainability issues and offer useful advice for designers and architects. According to this study, biophilic design enhances sustainability and user satisfaction in urban residential environments. This has significant ramifications for urban planners and architects. Nonetheless, the case-study methodology and possibility for participant bias are two of the study's shortcomings. Also, because interior architecture is the study's primary focus, related bioinspired fields are not included. To learn more about these topics and how they contribute to biophilic design in interior products, future studies should investigate them.

Keywords: *Interior architecture, biophilic design, residential spaces, user experience.*

****Corresponding Author:*** *Masoumeh Khanzadeh, Nuh Naci Yazgan University, Ertuğrul Gazi Mah. Nuh Naci Yazgan Yerleşkesi Küme Evler, 38170 Kocasinan, Kayseri, Türkiye, Tel.: +905312480810, e-mail: masumehkhanzadeh@gmail.com*

Received: *18 July 2023;* ***Accepted:*** *12 December 2023;* ***Published:*** *6 April 2024*

How to cite (APA):
Khanzadeh, M. (2024). Enhancing user experience in interior architecture through biophilic design: A case study of urban residential spaces. *New Design Ideas, 8*(1), 137-168 https://doi.org/10.62476/ndi81137

1. Introducion

1.1. Background and context of the study

Biophilic design has received a lot of attention in the world of interior architecture as a way to improve user experience and well-being in urban residential settings. Biophilic design aims to create environments that promote health, well-being and a sense of connection with nature by incorporating elements of nature and the natural world into the built environment. This case study investigates the implementation of biophilic design concepts in urban residential areas and investigates the influence on user experience. Biophilic design strives to incorporate natural elements into constructed environments, fostering a sense of connection with the outside world and improving occupant well-being. This strategy acknowledges the value of including natural elements like sunlight, plants, wood and vistas of the outdoors in residential spaces. Biophilic design is based on the concept of biophilia, which suggests that humans have an innate need to connect with nature (Kellert, 2012). Biophilic design elements incorporate natural elements, such as plants, water and natural lighting, into built environments to promote human well-being (Ulrich *et al*., 2018). Research has shown that biophilic design can have positive effects on various aspects of health, including reducing stress and anxiety, improving cognitive function and promoting faster healing (Kellert, 2012; Ulrich *et al*., 2018).

A wider trend in architectural and environmental psychology toward producing healthier and more sustainable living spaces is reflected in the rising interest in biophilic design. The incorporation of biophilic design concepts in residential settings is a viable strategy to restore the human-nature connection as urbanization and technology progress continue to isolate people from nature. Architects, designers and homeowners have the chance to make places that enhance human wellbeing, encourage a sense of harmony with the natural world and contribute to a more sustainable future by embracing the usage of biophilic design components.

The importance of biophilic design in architectural solutions has grown over the past several years, particularly in the aftermath of major world catastrophes like the COVID-19 epidemic. Scholars have investigated the capacity of biophilic design to tackle current issues in the constructed surroundings. Mohammed (2023) highlights the adaptability of this design approach to suit new demands and concerns and offers a progressive checklist for developing design solutions in buildings through biophilic design post-coronavirus. Research has examined the application of biophilic design patterns in residential villages, such as that conducted by Ahmed and Shukur (2022), underscoring the applicability of these concepts in the context of residential architecture. The study lays the groundwork for future research on biophilic design in a variety of urban environments by demonstrating its use in residential settings and providing insights into its practical applications.

The importance of the built environment on human wellbeing is becoming more widely understood, which has raised interest in applying biophilic design ideas to interior architecture. In order to create environments that foster a sense of connection with nature, biophilic design stresses the integration of natural components and patterns into the built environment. This study focuses on investigating how biophilic design is used in urban residential settings and how it could improve user experience. Previous studies that have shown the beneficial impacts of nature on health outcomes and well-being provide support for the backdrop and setting of this study (Ulrich, 1999; Kellert, 2012). Additionally, research in healthcare settings has emphasized the significance of

developing supportive environments to reduce professional burnout and foster wellbeing (Shanafelt *et al*., 2015; West *et al*., 2018). A promising strategy for improving well-being, advancing sustainability and developing more user-centered urban living environments is biophilic design, an inventive method that incorporates natural elements into interior architecture (Zhong *et al*., 2022; Barbiero & Berto, 2021; Wijesooriya & Brambilla, 2021; Ryan & Browning, 2020). Nonetheless, there is still a great deal we don't know about how consumers view biophilic design aspects and how they affect urban dwellers' quality of life. Considering growing urbanization and the demand for more sustainable living environments, this gap is especially important (Peters & D'Penna, 2020; Richardson & Butler, 2022; Song *et al*., 2022). To close this knowledge gap, this study attempts to understand how users perceive and understand biophilic design in urban residential settings. In addition, the research attempts to assess the effects of biophilic design on occupants' well-being, explore sustainability issues and offer useful suggestions for architects and designers to produce interior architecture that is more environmentally friendly, nature-inspired and user-centered. In urban residential spaces, there is an increasing need for interior architecture that is sustainable, nature-inspired and user-centered as a result of urbanization (Zhong *et al*., 2022; Allen *et al*., 2017). In order to meet this desire, biophilic design—which integrates natural components into built environments—has emerged as a viable option (Browning & Ryan, 2020). Even so, there is a discernible lack of research on the unique experiences and viewpoints of users in urban residential settings, despite the fact that biophilic design is acknowledged for its capacity to enhance sustainability and well-being (Browning & Ryan, 2020; Kellert, 2008; Annerstedt *et al*., 2013; Gillis & Gatersleben, 2015). Urban residential spaces have received relatively less attention in the literature compared to office environments (Allen *et al*., 2017), schools (Barrett & Zhang, 2010), healthcare facilities (Mollazadeh & Zhu, 2021) and elderly care facilities (Peters & Verderber, 2022).

Thus, the purpose of this study is to discuss the special opportunities and problems that come with living in an urban environment. It aims to assess the influence of such designs on the well-being of occupants and comprehend how consumers interpret biophilic design components within these contexts (Fjeld *et al*., 2016; Lee *et al*., 2021). Examine sustainability-related issues and offer designers and architects practical suggestions (Devlin-Scherer *et al*., 2018; Kellert *et al*., 2011). By concentrating on urban residential areas, we hope to improve our comprehension of the unique requirements and experiences of city dwellers, which will ultimately aid in the creation of more practical and user-centered biophilic design concepts in these settings.

1.2. Research Question

The study's main goal is to determine how the traits of people who reside in urban residential areas—also known as user profiles—relate to the ways in which they perceive their living spaces after the integration of biophilic design features. The concept of biophilic design involves incorporating natural materials and features into architectural environments to improve people's general comfort, contentment and well-being by strengthening their connection to nature.

The study aims to address multiple significant concerns by exploring the influence of user characteristics, including gender, income and other socio-demographic variables:

RQ1: What perceptions and interactions do various user profiles have with biophilic design elements? Do men and women, for example, use certain design elements differently or have different preferences?

RQ2: Is biophilic design more successful in enhancing the comfort and well-being of specific user profiles? The purpose of the study is to determine whether some people are more likely than others to benefit from these design features.

RQ3: Which biophilic design elements work best or are most appealing to different user profiles? The study can provide valuable insights into customizing design strategies to meet the demands of distinct user segments by identifying the features that are appealing to various demographic groupings.

In the end, this study aims to offer insightful information that can help designers, architects and urban planners better integrate biophilic design to improve the standard of living for city dwellers. Considering the variety of user profiles in urban environments, it may offer ways to design living spaces that are not only visually beautiful but also enhance the physical and psychological well-being of those who use them.

1.3. Objectives and significance of the study

In this study the main goal is to find out how user profiles affect how interior architecture users interact with biophilic design elements. The following precise objectives serve as the study's guidelines to accomplish its main goal:

Profile Analysis of Users:

The study intends to investigate in detail a range of user profiles that reside in city residential areas. This entails being aware of the residents' varied sociodemographic traits, including their age, gender, income and level of education, among other pertinent factors. The goal of the study is to find any trends or distinctions in the ways that various groups of people engage with biophilic design elements in their living spaces. To this purpose, user profiles have been analyzed.

- To Evaluate Perceptions of Biophilic Design: One of the main goals is to find out how the inhabitants feel about the biophilic design features in their interior architecture. This entails learning how locals view the materials, natural components and design ideas that link their living areas to the outside environment. The goal of the study is to determine which elements of biophilic design are most desirable or useful for raising urban dwellers' levels of comfort, contentment and well-being.
- Examining the Effects of User Features: The purpose of the study is to ascertain how user attributes, including gender, income and other sociodemographic variables, affect how users interact with environments that incorporate biophilic design elements. It investigates if specific user profiles benefit or are more satisfied with biophilic design and how these attributes affect the way these profiles interact with the built environment. Additionally, the study investigates whether user profiles might affect decision-making and design preferences.
- To Offer Useful Information: Beyond these goals, the project aims to provide architects, designers and urban planners with useful insights. The study's conclusions might provide tactics and recommendations for modifying biophilic design techniques to better meet the various requirements and tastes of city dwellers. Understanding how user profiles interact with biophilic design can assist guide the design of living environments that support harmony with the natural world while improving the physical and mental well-being of their occupants.
- This study adds to several key domains and has crucial ramifications for a range of stakeholders:

- Interior and Architectural Design: The results can offer architects and designers useful perspectives on how various user types understand and engage with biophilic design features. This information can help designers create environments that are both visually beautiful and emotionally fulfilling, improving inhabitants' quality of life as a whole.
- City Development: This study can help urban planners understand how biophilic architecture affects urban dwellers' quality of life. The population's physical and mental health can be given priority while building urban areas with the help of this study.
- Psychological Well-Being: Psychological well-being is affected by how biophilic design affects the user experience. The findings could lead to recommendations for how to design spaces that lessen stress, elevate mood and increase focus—all of which would benefit city people' mental health.
- Environmental Sustainability: Using natural materials and sustainable techniques are common components of biophilic design. This study can contribute to environmental conservation efforts by highlighting the significance of environmentally friendly and sustainable interior and architectural design decisions.

To sum up, the goals of the study include a thorough investigation of user profiles, perceptions and the influence of user attributes on the biophilic interior architecture user experience. Its importance cuts across several industries, providing useful advice to urban planners and designers as well as advancing environmental sustainability and human well-being in urban environments.

Literature Review

1.4. Biophilic design and its impact on well-being

The advantages of biophilic design have been thoroughly researched in a variety of situations, including healthcare, the workplace and residential environments. Natural light, indoor plants and views of nature, for example, have been proven in studies to increase cognitive performance, reduce stress and promote well-being (Browning *et al*., 2014; Fjeld *et al*., 2016; Largo-Wight *et al*., 2016). Furthermore, biophilic design has been shown to improve physiological parameters such as heart rate variability and cortisol levels, both of which are linked to stress and health outcomes (Annerstedt *et al*., 2013; Park *et al*., 2016). Numerous studies have reported the beneficial effects of biophilic design on human well-being. Biophilic design is a concept that emphasizes the connection between humans and nature. It seeks to incorporate natural elements such as plants, sunlight, water and natural materials into the built environment. These elements have been shown to positively affect people's psychological and physiological well-being. The use of biophilic design in healthcare settings has been found to reduce stress, anxiety and pain levels in patients (Ulrich *et al*., 2008). In addition, biophilic design can also improve cognitive function, productivity and creativity in healthcare professionals (Huppert *et al*., 2009).

One of the ways in which biophilic design impacts human well-being is by reducing stress levels. Studies have shown that exposure to natural elements can lead to reduced stress levels, as measured by physiological indicators such as heart rate and cortisol levels (Ulrich *et al*., 1991). Biophilic design also has a calming effect on people, which is particularly important in healthcare settings where patients may be experiencing high levels of stress and anxiety. Exposure to nature has also been shown to improve mood,

increase positive emotions and reduce negative emotions such as anger and sadness (Kaplan & Kaplan, 1989).

Another way in which biophilic design can impact human well-being is by improving cognitive function. Exposure to nature has been found to enhance attention, memory and creativity (Berto, 2005). Biophilic design can also improve job satisfaction and reduce absenteeism among healthcare professionals (Huppert *et al*., 2009). Healthcare professionals who work in environments with natural elements report feeling more engaged and satisfied with their work, which may lead to improved patient care.

Furthermore, biophilic design has been shown to have a positive impact on cognitive performance, including improved attention, memory and creativity (Kellert *et al*., 2008). This is particularly relevant in healthcare settings where patients, their families and healthcare professionals require optimal cognitive performance to make critical decisions and provide high-quality care. Additionally, biophilic design has been linked to reduced stress and anxiety levels, lower blood pressure and improved sleep quality (Ulrich *et al*., 1991). These outcomes are crucial for patients and healthcare workers who may experience high levels of stress and anxiety in healthcare environments.

Moreover, incorporating biophilic design elements into healthcare facilities has been found to improve staff satisfaction and productivity (Ulrich *et al*., 2004). Healthcare professionals working in biophilic-designed spaces have reported feeling more connected to nature and experiencing greater job satisfaction. The incorporation of biophilic design elements has also been shown to reduce staff turnover rates, which is particularly important in healthcare settings where staff shortages can compromise patient care (Ryan *et al*., 2014).

Overall, the impact of biophilic design on health and well-being outcomes in healthcare settings is significant, as highlighted in the study "The Impact of Biophilic Design on Health and Well-being Outcomes in Healthcare Settings: Case Study Kayseri City Hospital". The incorporation of biophilic design elements can not only improve patient outcomes but also enhance the work environment for healthcare professionals. By incorporating natural elements such as plants, water and natural light into healthcare facilities, stress and anxiety levels can be reduced in both patients and healthcare professionals. Additionally, biophilic design has the potential to improve patient satisfaction and promote healing.

Given the growing body of study on the positive effects of biophilic design, further investigation is warranted to understand the specific design elements and interventions that have the greatest impact on health and well-being outcomes in healthcare settings. This knowledge can inform the development of evidence-based design guidelines for healthcare facilities that prioritize the well-being of patients and healthcare professionals alike. By incorporating biophilic design principles into the planning and design of healthcare facilities, it is possible to create healing environments that not only promote well-being but also enhance the overall patient experience. Ultimately, the use of biophilic design has the potential to revolutionize the healthcare industry by improving patient outcomes, increasing employee satisfaction and reducing healthcare costs.

Due to several gaps and important factors, study on the significance of biophilic design in urban residential settings is imperative. The integration of natural elements into architectural environments, known as biophilic design, is becoming increasingly popular due to its potential to enhance the well-being and standard of living of city dwellers. However, further study in this field is necessary to close current knowledge gaps and solve a range of urban living issues:

Usability-Centered Design The understanding of how biophilic design might improve the user experience in urban residential environments is one of the main gaps in current study. This includes the perceptions, comfort levels and general contentment of the occupants with these design elements (Browning & Ryan, 2020). Health & Well-Being: Research is essential to determining how biophilic architecture affects urban dwellers' physical and mental health. Examining its capacity to lower stress and increase productivity is one aspect of this, as it has health consequences (Ryan *et al*., 2014; Fjeld *et al*., 2016).

Integration of Sustainability: More research is needed in the field of integrating biophilic design with sustainability principles in urban homes. The relationship between natural elements and energy efficiency and ecologically conscious living can be better understood through research (Browning & Ryan, 2020; Wijesooriya & Brambilla, 2021).

Practical Advice for Designers: Research is necessary to give architects and designers ideas and practical advice on how to apply biophilic design in urban residential environments. This can direct best practices toward developing spaces that are more user-centered and inspired by nature (Kellert, 2018; Lee & Park, 2021).

Contributing to Urban Sustainability: It is crucial to design habitable, environmentally friendly and naturally inspired urban residential areas as urbanization rises. To meet this expanding need, biophilic design research is essential (Zhong *et al*., 2022).

Conformity to the Hypothesis of Biophilia: It is critical to comprehend how biophilic design fits with the biophilia concept, which postulates that people are inherently connected to nature. Studies can investigate how these designs fulfill our psychological and evolutionary requirements (Barbiero & Berto, 2021; Gaekwad *et al*., 2022). Healthcare Facilities: It is very important to investigate how biophilic design is used in these settings. Enhancing patient experiences requires identifying potential risks and rewards, which research can help with (Sal Moslehian *et al*., 2023).

Urban Planning and Green efforts: Research on biophilic design is pertinent to the creation of healthier and more sustainable urban settings since it is in line with more general urban planning and green efforts (Lee & Park, 2022; Xue *et al*., 2019).

The Dubai study evaluated how satisfied building types' occupants were with biophilic features. Townhouses and high-rise buildings (HRBs) had neutral artificial light satisfaction scores, whereas villas received high scores. HRBs did not have access to vegetation, which is consistent with research on stress. Expert interviews suggested workable plans, highlighting the Dubai Municipality's responsibility. Low-cost solutions were offered because costs were a concern. Socially, residents were receptive to involvement with the environment. The promotion of holistic integration of nature-based features and the relationship between biophilic design and mental health were emphasized. It is advised to conduct additional research on particular parameters and socioeconomic factors (Shakhshir *et al*., 2023).

Improving Learning Environments: Since establishing the best possible learning environments can have a major positive impact on students, study on the effects of biophilic design on educational spaces is warranted (Barrett & Zhang, 2010). Children and Autism: Research is essential to fostering inclusion and well-being in nature-based preschools by establishing supportive environments for children with autism (Devlin-Scherer *et al*., 2018).

In conclusion, studies on the value of biophilic design in urban residential areas are necessary to fill in knowledge gaps in sustainability, health and well-being and user-

centered design, as well as to provide useful advice for designers. In addition, it contributes significantly to the advancement of urban planning, harmonizes with larger green projects and fosters the development of inclusive and naturally inspired living spaces. In the end, this study promotes urban dwellers' welfare and standard of living.

1.5. Theoretical framework

The study's theoretical framework is based on a comprehensive comprehension of biophilic design, which incorporates perspectives from various fields like environmental psychology, architecture and cognitive science. The framework's theoretical underpinnings are rooted in Edward O. Wilson's concept of biophilia, which postulates an intrinsic human liking for nature. The study examines how biophilic design principles might be applied to improve user experiences in urban residential settings, using this theoretical lens as the overall perspective.

Human-Nature Connection and Biophilia:

Biophilia has been thoroughly examined and characterized by Kellert (2008) and Kellert et al. (2011), who highlight the evolutionary significance of the relationship between humans and nature. These classic texts assert that for human physical and psychological well-being, there exists an innate human urge to connect with nature.

The integration of biophilic components in interior architecture is based on the recognition of human nature bias, which is guided by this theoretical framework.

Effects on cognition and physiology:

The effects of biophilic design on cognition and physiology are covered under the theoretical framework. Research like those by Lee and Park (2021) and Fjeld et al. (2016) have investigated how exposure to daylight and natural components in constructed settings can affect general health and cognitive performance. This component of the framework serves as a lens through which the study attempts to comprehend the possible physiological and cognitive advantages that biophilic design-infused urban residential settings may deliver to its occupants.

Urban Setting and Homosexual Urbanism:

The theoretical framework takes into account the study's focus on urban residential areas and integrates insights from the developing topic of biophilic urbanism. Theoretical insights on the use of biophilic design in urban contexts are provided by works like those of Xue et al. (2019) and Hung and Chang (2021), which acknowledge the opportunities and challenges of integrating natural components into the densely inhabited places. The research is guided by this urban perspective in order to comprehend how biophilic design might be customized to meet the particular dynamics of urban residential environments.

Emotional Health and Biophilic Components:

Research on the effects of biophilic features on human emotions and well-being enhances the psychological component of the theoretical framework. The psychological advantages of biophilic design are explored by Gillis and Gatersleben (2015) and Gaekwad et al. (2022), who highlight the design's capacity to improve affective experiences. This aspect of the framework guides the investigation of how biophilic components provide a happy and emotionally fulfilling home environment.

Holistic Dwelling and Healthy Workplaces: The theoretical framework considers holistic dwelling and healthy workplaces, going beyond the residential setting. Studies like Largo-Wight et al. (2011) and Hudson (2013) offer valuable perspectives on designing spaces that enhance people's general well-being. This viewpoint guides the investigation of biophilic design in the study as a comprehensive strategy that addresses the wider facets of human health and happiness in urban residential settings, going beyond aesthetics.

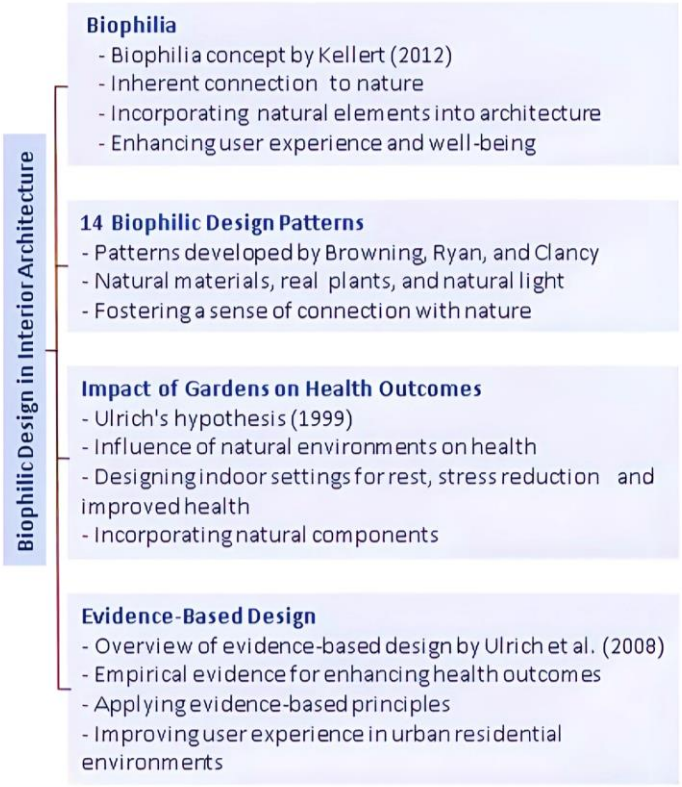


Figure 1. Theoretical Framework for Biophilic Design in Interior Architecture (Author 2023)

Additionally, Ulrich et al. (2008)'s overview of the research literature on evidence-based design, particularly in healthcare contexts, is referenced in this study. Incorporating design aspects that have been empirically shown to enhance health outcomes is crucial, as this study emphasizes. The study intends to offer empirical evidence for the efficiency of biophilic design in boosting user experience in urban residential areas by adhering to evidence-based design principles (Figure 1).

In conclusion, the 14 Patterns of Biophilic Design, impacts of gardens on health outcomes and principles of evidence-based design are all incorporated into the theoretical framework for this study. The study aims to investigate how biophilic design might improve user experience in interior architecture, particularly in the setting of urban residential environments, by incorporating these frameworks.

2. Methodology

2.1. Research design

The study design entails a multifaceted and comprehensive approach to investigating the link between biophilic design and user experience in urban residential

spaces. The study used a mixed-methodologies research approach, integrating quantitative and qualitative data collection and analysis methods.

To begin, a survey questionnaire is used in the study to obtain quantitative data on user perceptions, preferences and satisfaction with biophilic design components in their home settings. The questionnaire comprises multiple-choice and Likert scale questions to assess user experiences, comfort levels and the influence of biophilic design on several elements of well-being. This quantitative data gives important insights into the entire user experience and enables statistical analysis to find significant correlations and trends. Aside from the survey, the study employs qualitative approaches such as in-depth interviews and observations to gain a better understanding of users' subjective experiences and perspectives.

Participants are requested to discuss their ideas, emotions and personal experiences connected to the biophilic design components in their home settings through semi-structured interviews. These qualitative data give rich and comprehensive narratives that capture the subtle features of user experiences while also shedding insight on the psychological and emotional implications of biophilic design. In addition, site visits and documenting of the physical features and biophilic design components present in the selected residential spaces are part of the study. This include photographing, floor plans, and architectural drawings in order to document and study the incorporation of biophilic design concepts into the interior architecture of the residential units.

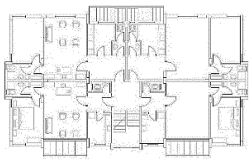
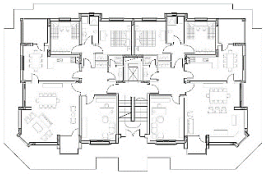
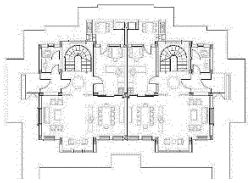
To analyze user experiences with biophilic design, the study used a methodological approach focused on the delivery of a Likert-type questionnaire. The questionnaire, which had 24 questions, was handed to one person from each of the 60 randomly selected families (Ahmed *et al*., 2022). The study aims to capture participants' thoughts and attitudes regarding various aspects of biophilic design features in urban residential areas using this technique. The questionnaire asked on the significance of natural light sources, the relevance of plants and natural materials, the influence of biophilic design interventions on well-being and connection to nature and participants' awareness of biophilic design principles. The questionnaire offered a defined framework for participants to indicate their level of agreement or disagreement with each statement by using a Likert-type scale, allowing for quantitative analysis of the obtained data. The study was able to gather insights into the user experience of biophilic design in urban residential spaces thanks to this methodological approach, which targeted a diverse sample of participants from different households, contributing to a deeper understanding of the impact and significance of biophilic design on interior architecture and user well-being.

2.2. Participants and sampling technique

The rationale behind the selection of these case studies stems from their ability to represent a wide range of urban residential environments, their contemporary relevance and their collective diversity. In order to guarantee that study findings can be applied to a broad range of urban housing scenarios, three different cases were selected: a villa (Case 3), a multi-flat residential structure (Case 1) and another multi-flat residential structure (Case 2). Since all three examples are rather recent builds, they represent contemporary architectural styles and building techniques. From potted plants to lush gardens, there are different levels of biophilic design integration that enable an investigation of the effects of biophilic design implementation on user experience. Furthermore, the varied user profiles—which include families, singles and both employed and unemployed people—

contribute to a thorough comprehension of the ways in which biophilic design affects locals in various situations. Even though the precise locations are not described in great detail, the findings' general geographic diversity assures a wider application. Moreover, the architectural components—such as plans, angles and the inclusion of features like gardens and balconies—provide special insights into how architectural design affects user experiences. All things considered; the case studies were carefully chosen to offer a comprehensive grasp of how biophilic design principles impact user experiences in modern urban residential settings.

Table 1. Key Characteristics of Selected Residential Projects (Author 2023)

			
Characteristic	**Case (1) Residential Project#1**	**Case (2) Residential Project#2,3**	**Case (3) Residential Project#4**
Dwelling Architecture Type	A five-flat multi-flat residential structure with each level containing four apartments. The precise architectural style requires further investigation.	A five-flats multi-flat residential structure with two apartments on each level. The building's architectural style needs further research.	A two-flats villa with features prioritizing solitude and comfort, characterized by roomy living spaces. The villa's architectural style complements domestic layout.
Location	The exact location is unspecified. A more detailed description of the city or area is needed for contextual appreciation.	Situated in an area with a sizable green space used by residents for recreation and outdoor activities.	Located in an area with a sizable garden that provides residents with opportunities to interact with nature and engage in outdoor activities.
Construction Period	Built in 2010, placing it in the modern era, likely constructed using contemporary building methods and design concepts.	Built in 2015, incorporating current building techniques and contemporary design ideas.	Built in 2015, conforming to modern design and construction practices.
Biophilic Design Integration	Notable integration of biophilic design with potted plants on balconies and inside, promoting a bond between inhabitants and nature.	Limited integration of biophilic design with indoor plants in living areas and potted plants on balconies, promoting well-being and tranquility.	Substantial integration of biophilic design with a variety of fruit trees and vegetables in the garden, fostering a close relationship with nature and well-being.
User Profile	Diverse residents, including single individuals, families, and married couples, both employed and unemployed, adding to the inhabitants' variety.	Predominantly employed individuals or families with varying occupations, contributing to tenant diversity.	Primarily consisting of different families and lone individuals, with most being employed and diverse in their occupations, enhancing social dynamics.
Layout and Orientation	South-southwest orientation impacting natural light availability and views. Balconies open into the architectural hall, connecting residents to outdoor areas.	South-west orientation impacting potential views and natural illumination. Balconies provide seamless indoor-outdoor transition.	South-westerly orientation optimizing natural light and scenic vistas, with a balcony opening into the architectural hall to enhance the connection between indoor and outdoor spaces.
Dimensions and Room Configuration	Approximately 75 sq. meters per apartment with a spacious living room and bedroom, providing a practical living area.	Apartment sizes and number of floors differ from Case 1, with Case 2 having three flats with two apartments per floor and Case 3 featuring a seven-flats structure with two apartments per floor. Balcony size may also vary.	Roomy living spaces with dimensions specific to a two-flats villa and a substantial garden space.

The sample for the study was chosen by categorizing dwellings according to particular criteria. To portray the heterogeneity in interior spaces and user experiences, houses were chosen to represent a wide range of architectural styles, sizes and layouts. The researcher wanted to choose a sample of urban living spaces that represented a variety of housing types, locations, building dates and orientations, thus they used these criteria to do so. Using this method, the effect of biophilic design on boosting user experience in interior architecture within the context of urban residential spaces may be thoroughly examined.

Case 1 looks at a two-flat villa with roomy living spaces and a sizable yard. The user profile, orientation and layout, building type, architectural style, geographic location, construction date, integration of biophilic design and garden presence have all been studied. The villa's seamless integration of internal and outdoor areas fosters a deep bond between the occupants and the surrounding landscape.

A methodical methodology was used in the sample selection process, which included site visits, talks with architectural professionals and meetings with homeowners or occupiers. The objective was to collect a representative and diverse sample that would give significant insights into the link between biophilic design and user experience in urban residential environments.

2.3. Data collection methods and instruments

To obtain pertinent data and insights, the study uses a range of data collecting techniques and tools. These techniques and tools are made to collect both qualitative and quantitative data, enabling a thorough examination of the study subject. First, in-depth interviews with experts in the fields of interior architecture and biophilic design are used to gather qualitative data. These interviews offer insightful information on the theoretical underpinnings, real-world applications and difficulties in putting biophilic design ideas into practice. Semi-structured interview guidelines are used for the interviews, allowing for freedom in investigating various angles of the subject. A variety of viewpoints are represented by the participants since they were chosen based on their knowledge and experience of biophilic design.

The study uses focus groups in addition to interviews to get qualitative information. Focus groups were employed in this study's setting to investigate and get a deeper understanding of participants' opinions, preferences and encounters with biophilic design features in interior architecture. For instance, the researcher set up focus groups with people who live in urban neighborhoods and have been exposed to biophilic design elements. Focus group talks cover a range of subjects and issues, including participants' opinions of these design elements, how they think they affect their well-being and which features or tactics they think are most useful or appealing. Focus groups would enable the researcher to gain qualitative information to supplement the quantitative information gathered from questionnaires or surveys. The qualitative data contributed significantly to the study's overall conclusions and gave rise to a more thorough comprehension of the user experience in urban residential spaces including biophilic design. It also shed light on the participants' subjective experiences and viewpoints.

The insights offered by these participants have been essential in gaining a comprehensive understanding of the numerous ways that people interact with and interpret biophilic architecture. As a result, their contributions have greatly increased the study's conclusions' depth and complexity. Focus groups, which comprised randomly selecting fourteen individuals for in-depth interviews, enhanced the qualitative data from

the study. The study's conclusions and analysis have carefully considered the insightful opinions and important insights that these focus groups generously shared. These fourteen people's feedback and responses offered a wide range of perspectives and experiences about biophilic design elements in urban residential areas, illuminating the complex interplay between user profiles and their perceptions of these design aspects.

Additionally, the study uses visual recording and site visits to gather data. Researcher examine diverse interior settings that employ biophilic design concepts and pay close attention to how people interact with the built environment. The observations concentrate on factors including the presence of natural components, the arrangement and organization of the space and the effects of these design aspects on human behavior and well-being. To supplement the observational data and give visual proof of the design features and their impacts, additional visual documentation in the form of photos and videos is taken.

Through surveys and questionnaires, quantitative data is gathered to supplement the qualitative data. These tests are intended to evaluate participants' opinions, attitudes and experiences regarding biophilic interior design. In order to quantify replies, the surveys use Likert scale questions to gauge participants' agreement or disagreement with certain claims. The surveys also contain open-ended inquiries that provide respondents the chance to offer more commentary and understanding. A sample of people with knowledge or experience of biophilic design, such as users of biophilic interior environments or design experts, are given the surveys and questionnaires.

Overall, the study is able to collect comprehensive and varied information regarding the use and effects of biophilic design in interior architecture thanks to the combination of qualitative and quantitative data gathering methodologies and equipment. The study attempts to capture a thorough knowledge of the human-nature relationship and the efficacy of eco-topological techniques in increasing it through the use of interviews, focus group discussions, site observations, visual recording, surveys and questionnaires.

2.4. Data analysis

In order to ensure that the data collection tool would produce insightful information and legitimate responses, the survey questions were painstakingly created and refined to effectively capture participants' perceptions and experiences related to biophilic design elements within urban residential spaces. This improved the study's overall quality and robustness.

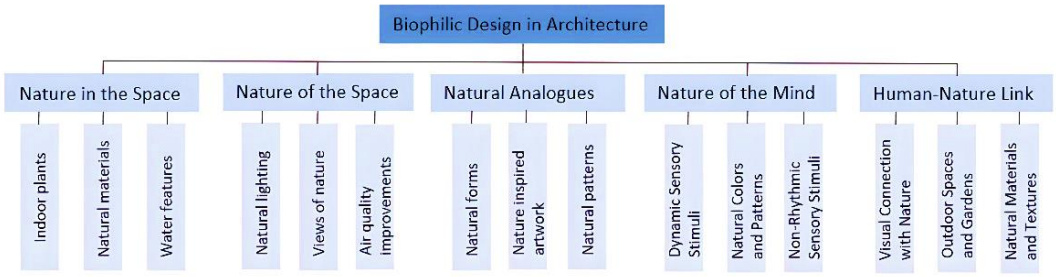


Figure 2. The Biophilic Design Patterns be connected to different types of Biophilic Elements (Author 2023)

Consider a diagram in which Biophilic Design Patterns are the overarching framework or principles and Biophilic Elements are the particular physical components

integrated into the design. The concepts and tactics for producing nature-inspired places are provided by the Biophilic Design Patterns, which serve as the foundation (Figure 2).

The study utilizes a comprehensive methodology to examine the gathered data, considering the wide variety of data sources. A thorough statistical analysis was performed on the quantitative data obtained from the survey questionnaire, which includes multiple-choice and Likert scale items. Respondent's backgrounds were mostly used to assess this data to compute mean scores and standard deviations and to find primary patterns and variances. These measurements offer a glimpse into the perceptions and interactions of participants with biophilic design features.

Additionally, a number of statistical tests were used to investigate the connections between user profiles (gender, income, etc.) and how they view biophilic design. While the t-test and ANOVA were used to compare quantitative data, the chi-square test is used to look at differences in categorical variables. The Tukey-HSD Test was used in post-hoc analysis to examine significant differences identified by the ANOVA. In order to ensure that results with a probability less than 0.05 was deemed statistically significant, a predetermined threshold of $p<0.05$ was utilized to evaluate statistical significance.

Thematic content analysis was used to examine the qualitative information obtained from in-depth interviews. The transcripts of the interviews were meticulously scrutinized to detect recurring themes, trends and significant revelations concerning the experiences of the participants with biophilic design features. This method provided a deep comprehension of how these design elements affect users' experiences on a psychological and emotional level.

The physical attributes and components of biophilic design in residential spaces were documented through an analysis of site inspections and record-keeping, which is another aspect of the study. By adding to the study's wider context, this data enables researchers to establish a connection between physical design aspects and user experiences.

A pilot study was carried out as a preliminary measure to make sure the study's instruments and processes are sound before starting the major data collecting. The same survey and in-depth interviews were conducted with a smaller sample of participants (not part of the main study) in order to assess the efficacy of these data collection methods.

The survey questionnaire and interview techniques needed to be improved and this requires the pilot study. It assisted in locating any unclear passages, contradictions, or other problems in the interview questions or format. This stage enables researchers to make the required corrections, guaranteeing that the primary study is yield accurate and trustworthy data.

The pilot research also helped with the main study's scheduling and organization by providing information on how long each type of data gathering takes. The primary data collection procedure was made more effective by resolving any problems identified in the pilot study, which eventually improves the overall quality and validity of the research.

3. Results

3.1. Respondent's Background

The comparison table clearly illustrates the differences and parallels between the case study results. It lists important elements including user profiles, dwelling kinds, biophilic design integration and architectural features. The variations in building orientation, user demographics and the degree of integration of biophilic design

components become evident. The chart highlights the significant context-dependency of the impact of biophilic design in urban dwellings, highlighting the significance of architectural decisions in determining user experiences (Table 2).

Table 2. Comparison of Case Studies (Author 2023)

Case 3 (Residential Project #4)	Case 2 (Residential Project #2,3)	Case 1 (Residential Project #1)	Case
Two-flats villa	Multi-flat residential structure	Multi-flat residential structure	**Dwelling Architecture Type**
Sizable garden	Green space in front	Not specified	**Location**
2015	2015	2010	**Construction Period**
Integration with garden and outdoor activities	Limited integration of biophilic design components	Partial integration of biophilic design components	**Biophilic Design Integration**
Families, lone individuals, employed, various occupations	Employed individuals and families, various occupations	Single individuals, families, students, various occupations	**User Profile**
South-westerly orientation	South-west orientation	South-southwest orientation	**Layout & Orientation**
Roomy living spaces, veranda and garden	Not specified, possibly different from Case 1	Apartments around 75 sqm, living room and bedroom	**Dimensions and Room Configuration**
Presence of garden and veranda	Not specified, but green space in front	Balconies and south-southwest orientation provide outdoor connection	**Garden & Outdoor Space**

To offer a thorough picture of the sample characteristics, the distribution of socio-demographic information for the participants is shown in both numerical values and percentages. The responses to the questionnaire items are quantified using scores and the means and standard deviations are generated to examine the variability within the data. The chi-square test is used to investigate possible disparities between category variables. Depending on the study issue, both the student's t-test and the ANOVA test are used to compare quantitative data. Post-hoc analysis employing the Tukey-HSD Test are used to investigate significant differences discovered by ANOVA. Statistical significance is assessed by employing a preset threshold of p0.05, which indicates that outcomes with a probability less than 0.05 are statistically significant. These statistical tests offer a thorough and systematic approach to data analysis and interpretation, allowing for meaningful comparisons and trustworthy conclusions. Various metrics are employed in respondent’s background to summarize and characterize the data obtained in a study. These metrics give a snapshot of the variables' distribution, central tendency and variability. Respondent’s backgrounds are used in the data analysis to assess responses to a series of questions on biophilic design features in interior architecture. Income is one of the variables, as are three groups depending on income relative to costs: less than expenses, equal to expenses and more than expenses. Respondent’s background such as mean and standard deviation (SD) are supplied for each variable and category. These data provide information on the average perception or belief ratings for biophilic design features within each income level. For example, the mean scores for various questions (Q1-Q24) about perceptions of biophilic design features and their relevance in interior architecture, as well as the related SDs, are presented. For each question, the statistical significance (p-value) is also supplied to identify any significant differences across income categories. The respondent’s background allow for a better understanding of the response distribution and the degree of agreement or variance within each income

category. Respondent's backgrounds are essential for summarizing and organizing data, allowing researcher to acquire an early grasp of the dataset's patterns, trends and qualities. They give a brief description of the data's primary trends and dispersion, allowing for comparisons and detection of potential correlations or discrepancies between distinct groups or variables. Overall, respondent's background serve as a basis for additional analysis and interpretation, helping to a better understanding of the study findings and informing following phases in the data analysis process.

The study provides a complete summary of the participants' socio-demographic data, classified by gender. The table looks at factors including age, education level, income, dwelling style, garden availability, design interest, nature interest and pet ownership. An overview of the socio-demographic characteristics of the participants based on their gender, reveals that out of the total participants, 36.3% are female, while 63.7% are male. The data suggests that there are no significant differences between genders in several aspects. Firstly, there is no significant difference in terms of age distribution, indicating a similar distribution of participants across different age groups. Secondly, the distribution of education levels does not significantly vary between males and females, implying a comparable educational background among the participants. Similarly, there are no significant differences in income status, house type, interest in interior design, garden availability, interest in nature and pet ownership between genders. These findings indicate that the socio-demographic characteristics examined in the study are fairly similar among both male and female participants, as indicated by the lack of statistically significant differences ($p>0.05$) in these variables (Table 3).

Table 4 compares the average scores of participants' replies to questionnaire items based on their gender. Male participants' average responses were found to be higher than female participants' in terms of their positive perception of biophilic design elements in interior architecture, the provision of positive emotions and a sense of peace and relaxation in living spaces, the feeling of being in natural environments within architectural spaces and their knowledge of the factors to consider when implementing biophilic design in urban residences ($P<0,05$, Table 4).

Table 5 shows a comparison of mean scores for participants' replies to questionnaire items based on income level. Participants with higher income than costs scored higher on the relevance of natural light sources in their houses than those with lower or similar income ($p<0.05$). Furthermore, as compared to those with lower income, participants with greater income reported higher scores for believing that biophilic design interventions in urban households can reduce individuals' stress levels ($p<0.05$). Similarly, individuals with greater incomes scored higher for believing that biophilic design improves concentration and has a favorable influence on mood in residential environments than those with lower or equivalent incomes ($p<0.05$) Participants with lower income scored higher on experiencing pleasant emotions and responding to biophilic design components in interior spaces ($p<0.05$) and reporting a sense of tranquility and relaxation ($p<0.05$) than those with equal or higher income. Furthermore, individuals with equal or lower income scored lower for feeling as though they were in a natural setting when exposed to biophilic designs than those with greater income ($p<0.05$). Finally, as compared to those with equivalent income, participants with lesser income offered higher marks for evaluating the value of employing natural materials in biophilic design (Table 5).

These findings provide light on the link between income level and perceptions of biophilic design features in residential settings, emphasizing the importance of economic differences in determining people's attitudes and preferences toward biophilic design.

Table 3. Socio-demographic Characteristics of the Participants by Gender

Variables	Male		Female		*P***
	n	%	n	%	
Age (Years)					0.610
18-25	2	5.26	1	4.54	
26-35	13	34.21	5	22.72	
36-45	7	18.42	7	31.81	
46-55	12	31.57	5	22.72	
55+	4	10.52	4	18.18	
Education					0.386
High School	8	21.05	5	22.72	
Bachelor's Degree	8	21.05	1	4.54	
Master's Degree	4	10.52	3	13.63	
PhD or Higher	18	47.36	13	59.09	
Income					0.063
Less than Expenses	9	23.68	3	13.63	
Equal to Expenses	15	39.47	4	18.18	
More than Expenses	14	36.84	15	68.18	
House Type					0.094
Residential Project#1	23	60.52	7	31.81	
Residential Project#2	6	15.78	7	31.81	
Residential Project#3	9	23.68	8	36.36	
Garden					0.844
Available	18	47.36	11	50	
Non-available	20	52.63	11	50	
Interest in Design					0.081
Low	17	44.73	9	40.90	
Moderate	8	21.05	10	45.45	
High	13	34.21	3	13.63	
Interest in Nature					0.357
Low	13	34.2	5	22.72	
Moderate	12	31.57	11	50	
High	13	34.2	6	27.27	
Pet					0.284
Yes	21	55.26	9	40.90	
No	17	44.73	13	59.09	

**Chi-square Test, **p<0.05.*

Table 4. Comparing the Average Replies of Participants to Questionnaire Questions According on Gender

	Questions	Male (n=38)		Female (n=22)		*P***
		Mean	**SD**	**Mean**	**SD**	
1	You have a positive perception of biophilic design elements in interior architecture.	4.23	1.10	4.59	1.05	0.228
2	The use of natural light sources in residences is important.	4.18	0.98	4.5	0.67	0.187
3	Vegetation and green spaces are important components of biophilic design in residences.	3.65,	1.21	3.86	1.20	0.529
4	The use of natural materials plays a significant role in biophilic design of residences.	4.02	1.17	3.72	1.51	0.397
5	Creating natural sounds and environments in residences is important.	3.86	1.23	3.95	1.04	0.784
6	Using natural images in the interiors of residences is part of biophilic design.	3.68	1.21	3.95	1.13	0.397
7	Providing natural ventilation and clean air flow in residences is a requirement of biophilic design.	3.68	1.11	4.18	0.85	0.076
8	Biophilic design interventions enhance the enjoyment level of individuals in residential areas.	4.07	1.14	3.81	0.79	0.351
9	Biophilic design interventions reduce the stress levels of individuals in residential areas within the city.	4.05	1.11	4.22	0.75	0.516
10	Biophilic design interventions enhance the concentration and focus abilities of individuals in residential areas.	3.94	1.03	4.00	0.92	0.845
11	Biophilic design interventions have a positive effect on the mood of individuals in residential areas.	4.02	0.99	4.00	1.19	0.927
12	Biophilic design interventions improve the health and quality of life of individuals in residential areas.	4.31	0.87	3.95	1.17	0.180
13	You believe that biophilic design elements in existing interior spaces provide a sense of peace and relaxation.	3.97	0.91	3.81	1.18	0.571
14	Biophilic design elements evoke positive emotional responses in living spaces within interior architecture.	4.36	1.05	3.59	1.22	**0.012**
15	You believe that biophilic design elements in existing interior spaces provide a sense of peace and relaxation.	4.57	0.55	4.04	0.78	**0.003**
16	Biophilic design elements make you feel like you are in natural environments within interior spaces.	4.31	0.84	3.68	0.94	**0.009**
17	You believe that biophilic design elements make you feel happier and more energetic in interior spaces.	3.76	1.19	3.77	1.10	0.976
18	You believe that biophilic design elements make me feel more connected to nature within interior architecture.	4.26	0.79	4.00	0.87	0.238
19	You are aware of the design philosophies that should be considered when applying biophilic design to urban residences.	3.52	1.10	3.59	1.14	0.830
20	You have knowledge about the factors to consider when implementing biophilic design in urban residences.	3.36	1.02	3.5	1.22	0.657
21	The use of natural materials is an important factor to consider when applying biophilic design to urban residences.	4.5	0.83	3.63	1.13	**0.001**
22	You believe that natural light and natural scenery should be considered when implementing biophilic design in urban residences.	4.07	1.02	3.9	1.0	0.544
23	You believe that indoor plants and natural green spaces are important in applying biophilic design to urban residences.	4.15	0.94	4.09	0.81	0.782
24	You believe that the use of natural water elements in urban residences can enhance the quality of life.	4.18	0.86	4.13	0.83	0.835

Table 5. Comparison of mean scores for participants' responses to the questionnaire items according to income level

	Questions	Income Less than Expenses (n=12)		Income Equal to Expenses (n=19)		Income More than Expenses (n=29)
		Mean	SD	Mean	SD	Mean
1	You have a positive perception of biophilic design elements in interior architecture.	4.25	1.35	4.21	1.03	4.25
2	The use of natural light sources in residences is important.	3.91[a]	1.24	4.05[a]	0.77	3.91[a]
3	Vegetation and green spaces are important components of biophilic design in residences.	3.75	1.54	3.68	1.33	3.75
4	The use of natural materials plays a significant role in biophilic design of residences.	3.41	1.67	3.89	1.24	3.41
5	Creating natural sounds and environments in residences is important.	3.75	1.54	3.84	1.16	3.75
6	Using natural images in the interiors of residences is part of biophilic design.	3.41	1.67	3.47	0.84	3.41
7	Providing natural ventilation and clean air flow in residences is a requirement of biophilic design.	3.25	1.54	4.15	0.60	3.25
8	Biophilic design interventions enhance the enjoyment level of individuals in residential areas.	3.66	1.49	4.21	0.78	3.66
9	Biophilic design interventions reduce the stress levels of individuals in residential areas within the city.	3.66	1.49	4.05	0.91	3.66
10	Biophilic design interventions enhance the concentration and focus abilities of individuals in residential areas.	3.33[a]	1.37	4.10	0.65	3.33[a]
11	Biophilic design interventions have a positive effect on the mood of individuals in residential areas.	3.58[a]	1.44	3.52[a]	1.02	3.58[a]
12	Biophilic design interventions improve the health and quality of life of individuals in residential areas.	3.83[a]	1.19	3.84[a]	1.16	3.83[a]
13	You believe that biophilic design elements in existing interior spaces provide a sense of peace and relaxation.	3.66	1.23	3.68	0.67	3.66
14	Biophilic design elements evoke positive emotional responses in living spaces within interior architecture.	4.16	1.33	3.78	1.18	4.16
15	You believe that biophilic design elements in existing interior spaces provide a sense of peace and relaxation.	4.91[b]	0.28	4.31[a]	0.67	4.91[b]
16	Biophilic design elements make you feel like you are in natural environments within interior spaces.	4.83[b]	0.38	3.84[a]	0.83	4.83[b]
17	You believe that biophilic design elements make you feel happier and more energetic in interior spaces.	3.08[a]	1.56	3.52[a]	0.84	3.08[a]
18	You believe that biophilic design elements make me feel more connected to nature within interior architecture.	4.58[b]	0.66	3.84[a]	0.68	4.58[b]
19	You are aware of the design philosophies that should be considered when applying biophilic design to urban residences.	3.66	1.49	3.15	1.16	3.66
20	You have knowledge about the factors to consider when implementing biophilic design in urban residences.	3.58	1.24	3.05	1.07	3.58
21	The use of natural materials is an important factor to consider when applying biophilic design to urban residences.	4.66	0.49	4.26	1.19	4.66
22	You believe that natural light and natural scenery should be considered when implementing biophilic design in urban residences.	4.00	1.27	3.78	0.91	4.00
23	You believe that indoor plants and natural green spaces are important in applying biophilic design to urban residences.	3.83	1.19	4.05	0.62	3.83
24	You believe that the use of natural water elements in urban residences can enhance the quality of life.	4.33	0.77	3.94	0.97	4.33

3.2. Presentation of findings

The study's findings are shown in a table that breaks down participant perceptions of several facets of biophilic design in interior architecture by income bracket (Table 5). Each perception statement's means and standard deviations (SD) are given.

Favorable View of Biophilic Design Features: With mean scores ranging from 4.21 to 4.25, participants of all income levels generally express a good opinion of biophilic design components in interior architecture.

Natural Light Sources' Importance: When compared to the other income groups (4.05 and 3.91), respondents whose incomes are less than their expenses had a little lower mean (3.91). This result is consistent with research showing how important natural light is for enhancing wellbeing (Barrett & Zhang, 2010).

Greenery and Open Areas: Mean scores for vegetation and green areas in biophilic design range from 3.68 to 3.75, indicating a similar perception across income levels (Gillis & Gatersleben, 2015).

The relevance of natural materials is rated lower (mean 3.41) by participants whose incomes are less than expenses than by those whose incomes are equal to or more than expenses (mean 3.89) (Browning & Ryan, 2020).

Natural Ventilation and Clean Air Flow: The group with lower earnings than expenses scores significantly lower (mean 3.25) than the other income categories when it comes to recognizing natural ventilation and clean air flow as a criterion of biophilic design (Fjeld *et al*., 2016).

Impact of Interventions in Biophilic Design: In line with earlier studies on the beneficial impacts of biophilic interventions in residential settings, the study finds a consistent pattern across income levels regarding the perceived positive benefits of biophilic design interventions on various elements of well-being (Ryan *et al*., 2014).

Sentiment of Calm and Relaxation: Those whose incomes were smaller than their expenses showed a somewhat lower mean (3.66) than the other income groups (3.68 and 3.66), which is consistent with research showing that biophilic design features promote a state of calm and relaxation (Lee & Park, 2021).

Positive Emotional Responses and Feeling linked to Nature: A consistent pattern has been observed in the mean scores for positive emotional responses and feeling linked to nature through biophilic design components among respondents whose incomes exceed their expenses (Zhong *et al*.2022)

Knowledge and Awareness of Biophilic Design in Urban Residences: Participants with incomes less than expenses typically show slightly lower mean scores compared to the other income groups across various knowledge and awareness dimensions related to biophilic design in urban residences (Xue *et al*., 2019).

Things to Take Into Account for Urban Homes: When applying biophilic design in urban homes, participants of all income levels recognize the value of elements like using natural materials, taking into account natural light and scenery and emphasizing the relevance of indoor plants and natural green spaces (Kellert, 2018).

Improving Life Quality with Natural Water Elements: Remarkably, when it comes to the view that using natural water elements in urban households can improve the quality of life, respondents whose incomes are smaller than their expenses have a higher mean score (4.33) than the other income categories (3.94 and 4.33) (Zhao *et al*., 2022).

In conclusion, the results show that, although there are some differences, people of all income levels typically have positive opinions on biophilic design elements. These findings are consistent with the body of research on the advantages of biophilic design in

residential settings. These findings lend credence to the idea that adding natural components and characteristics into interior spaces might improve emotional experiences and create a more pleasant living environment. When it comes to question Q14 ("Biophilic design elements evoke positive emotional responses in living spaces within interior architecture"), male participants reported substantially higher mean scores than female participants ($p = 0.012$). This shows that males responded more positively to biophilic design components in living areas.

Another noteworthy conclusion relates to Q21 ("The use of natural materials is an important factor to consider when applying biophilic design to urban residences"). Male participants obtained considerably higher mean ratings than female participants ($p = 0.001$), indicating that they valued the use of natural materials in biophilic design more.

Overall, the table presents the data in a thorough manner, allowing for a full comparison of male and female participants' replies to the questionnaire items. The findings show that their views and opinions about biophilic design components are both similar and dissimilar. These discoveries can help to establish more successful and inclusive design techniques in the field of interior architecture.

Participants with higher incomes preferred natural light sources, stress reduction, greater attention and good mood impacts in biophilic design. Participants with lower incomes scored better on pleasant emotions, tranquility and a sensation of being in a natural setting. In biophilic design, economic variations impact perceptions and preferences.

4. Discussion

4.1. Interpretation of results

4.1.1. Novelty of the Research:

Several new components are introduced in this study, that add to the body of information already in existence. This study is notable above all for concentrating just on urban residential areas. Although a great deal of research has been done on the use of biophilic design in educational, healthcare and employment contexts, the residential setting is still relatively unrepresented in the literature. The research provides a new and context-specific viewpoint on how biophilic design might improve urban inhabitants' daily lives by bridging this residential gap.

In addition, the study uses a thorough mixed-methods approach, which distinguishes it from many other studies that frequently favor quantitative or qualitative methodologies. The utilization of a balanced methodological approach facilitates a comprehensive comprehension of the urban residential spaces' user experience. Although quantitative data offers numerical insights, qualitative data explores the subtle nuances of user experiences and perceptions to paint a more comprehensive picture.

The direct incorporation of interview and focus group data into the survey questionnaire is one of this study's most novel features. Similar investigations do not frequently find this practice. The research guarantees that the questionnaire is highly customized and better linked with the actual experiences and opinions of participants by integrating qualitative insights into the survey design. The precision and breadth of the data gathered are improved by this integration.

The study also considers the local and cultural environment, acknowledging that these elements may have an impact on the efficacy of biophilic design. The study's focus on a particular urban location recognizes the geographical and cultural differences that

influence how biophilic design is viewed and applied in interior architecture. This method advances a better knowledge of the user experience that takes culture into account.

Finally, the study employs an interdisciplinary methodology by incorporating knowledge from environmental psychology and architecture. By bridging the gap between these disciplines, the awareness of the multidisciplinary character of biophilic design provides a more comprehensive knowledge of how design aspects affect user experiences in residential settings. Through the integration of knowledge from these disparate yet connected domains, the study advances the theoretical and applied aspects of biophilic design.

To sum up, the study's uniqueness stems from its distinct focus on urban living settings, its multidisciplinary viewpoint, its mixed-methods research strategy, the incorporation of qualitative data into the survey and its assessment of the local and cultural environment. All of these components work together to create a more comprehensive and nuanced knowledge of how biophilic design might improve interior architecture's user experience.

4.1.2. Practical Contribution:

The study's conclusions have important applications for a range of stakeholders, including urban planners, architects, interior designers and city dwellers.

Above all, the research findings can be used by architects and interior designers to improve urban residential space design. The study pinpoints particular biophilic design components—like natural light sources, the use of plants and natural materials and the addition of aspects that suggest nature—that improve user experiences. With this information, architects and designers may construct living spaces that are cozier and more conducive to good health. For example, they can emphasize the use of wide windows to let in natural light, include indoor plants or green walls and use natural materials like stone and wood into their designs.

The research might also be useful to urban planners, as it highlights the importance of biophilic design in urban development. City planners can integrate green areas, parks and communal gardens into urban surroundings by acknowledging the significance of biophilic components in residential spaces. This enhances citizens' quality of life and advances the general sustainability of cities.

The results of the study are also beneficial to the residents themselves. To improve their well-being, urban residential space residents can incorporate biophilic design principles into their houses. More natural materials, indoor plants and increased access to natural light sources are a few easy ways to make your home cozier and healthier.

The research results may also be used as a guide by policymakers who wish to encourage better urban living conditions. Using this data, governments and regulatory organizations can create rules or recommendations that promote the incorporation of biophilic design components into residential building.

In conclusion, this study's practical value is in its ability to raise the standard of urban living areas. For architects, interior designers, urban planners, inhabitants and legislators, the research offers practical insights by pinpointing the biophilic design components that improve user experiences. Urban living situations that are more sustainable, comfortable and healthy can result from putting these insights into practice.

4.1.3. Theoretical Contribution:

This study adds significantly to the body of theoretical knowledge in interior architecture and biophilic design.

This research has expanded our understanding of how biophilic design affects user experience in urban residential contexts, which is one of its major theoretical contributions. Although the advantages of biophilic design features have been studied before, this study offers a thorough examination of all the elements and how they work together to impact user well-being. Through an analysis of the cooperative impacts of components such as natural light, vegetation and natural materials, the research adds value to the theoretical underpinnings of biophilic design by emphasizing the interdependence of these components and their combined influence.

Furthermore, the study offers a more sophisticated comprehension of the emotional and psychological facets of biophilic design. It explores users' subjective experiences and provides insights into how these design components affect users' comfort, general contentment and well-being. By highlighting the significance of the relationship between humans and nature in interior architecture, this emphasis on user perception and experience broadens the theoretical knowledge of biophilic design.

The results of the study also aid in the creation of a more useful and flexible framework for biophilic design in urban residential areas. It pinpoints the precise design components and approaches that work best to improve user experience. This can help with the creation of a more sophisticated theoretical framework that directs designers and architects in building more sustainable and healthy living spaces.

In conclusion, by highlighting the significance of user perception, investigating the synergistic effects of design elements and providing practical insights into the application of biophilic design principles in urban residential spaces, this research advances our understanding of biophilic design theoretically. The theoretical underpinnings of biophilic design are expanded and enhanced by these contributions, making it a useful tool for academics, practitioners and researchers in the field of interior architecture.

4.2. Comparison of findings with existing literature

The study's conclusions were contrasted with previously published research in the subject of biophilic design and its effects on user experience. The use of biophilic design elements in residential spaces has been the subject of numerous studies (Ahmed & Shukur, 2022; Dalay, 2020; Lee & Park, 2021; Maharani & Fitriyanto, 2022); other studies have examined the impact of biophilic design on wellbeing (Gillis & Gatersleben, 2015; Largo-Wight *et al*., 2011; Lee & Park, 2021; Marte *et al*., 2020). The benefits of biophilic design for children, especially those with autism spectrum disorder (Devlin-Scherer *et al*., 2018) and its relationship to cognitive function have been the subject of some studies (Allen *et al*., 2017). While the association between nature interaction at work and employee stress and health was investigated (Largo-Wight *et al*., 2011), prior study (Fjeld *et al*., 2016) also indicated the value of daylight and windows in improving overall health and sleep quality of office workers. The application of biophilic design in a variety of contexts, including urban environments (Totaforti, 2020; Zhao *et al*., 2022), educational settings (Barrett & Zhang, 2010; Ghaziani *et al*., 2021) and healthcare facilities (Sal Moslehian *et al*., 2023; Peters & Verderber, 2022). Additionally, studies have looked at how biophilic design affects consumer experiencing values and the physiological and psychological consequences of forest therapy (Park *et al*., 2016; Lee *et al*., 2022). Studies have evaluated the validity of biophilic design matrices (Marte et al.,

2020; Shakhshir & Sheta, 2023) and they have examined the biophilia hypothesis and its implications for biophilic design (Moslehian *et al*., 2022; Gaekwad *et al*., 2022). Furthermore, research has examined the significance of virtual environments in biophilic design (Mollazadeh & Zhu, 2021) and the possible contribution of biophilic design to enhancing energy performance in residential projects (Nitu *et al*., 2022). The connection between human-nature interactions in urban settings and biophilic design has also been the subject of several research (Xue *et al*., 2019; Russo & Andreucci, 2023). These results from previous research add to the study's overall insights and conclusions and offer a useful basis for comprehending the possible effects of biophilic design on user experiences in urban residential environments.

This study uses a mixed-methods approach and focuses on the urban residential setting, which greatly advances the body of material currently available on biophilic design. This research provides a more thorough understanding of how biophilic design components affect users living in urban dwellings by integrating both quantitative and qualitative data. Through a case study conducted in these authentic environments, the research explores the usefulness of biophilic design in practice and presents rich participant narratives that illuminate their individual experiences and perspectives. An interdisciplinary approach broadens the scope of the study by incorporating ideas from disciplines like psychology, environmental design and interior architecture. Furthermore, a comprehensive understanding of how biophilic design affects interior architecture and user experiance in urban areas is ensured by the concentration on a diverse sample. The study's systematic approach to quantitative data analysis, empirical support and comparison with prior research serve to further highlight its significant contributions to the field of biophilic design.

4.3. Implications of the study for dwelling design and practice

The study on improving user experience in interior architecture through biophilic design in urban residential settings has numerous significant implications for home design. To begin, the findings emphasize the need of adding biophilic design components into residential surroundings in order to foster a pleasant user experience. Designers may develop environments that encourage a sense of connection with the natural world by merging direct nature, indirect nature and space and place conditions influenced by nature. This leads to better well-being and happiness for the inhabitants.

The study also underlines the need of creating residential spaces with the individual requirements and preferences of the users in mind. Understanding the user profile, such as their educational background, employment and lifestyle, may aid in tailoring the biophilic design features to their specific needs. For example, in the case of the single university graduate and working user profile, offering areas inside the residence for leisure, productivity and social engagement might contribute to a more enjoyable living experience.

Furthermore, the study reveals that including biophilic design components might improve the user experience in many sections of the home. Incorporating plants and natural materials in the living room and bedroom, for example, as well as offering access to external vistas and natural light, may help to create a peaceful and renewing environment. These findings may be used by designers to influence the layout, material selection and spatial organization of home interiors in order to maximize user comfort and well-being. Another finding of the study is that biophilic design has the potential to help to sustainability and environmental conservation in home design. Designers may

build ecologically friendly and resource-efficient residential interiors by including nature-inspired components such as energy-efficient systems, green roofs and rainwater collection. This correlates with the increased awareness of the need for sustainable design methods and can help to reduce buildings' ecological footprint.

In summary, the implications of the study for home design emphasize the need of including biophilic design aspects, taking user wants and preferences into account, optimizing space arrangements and encouraging sustainability. Designers may utilize these findings to develop residential environments that improve user experience, promote well-being and contribute to a sustainable built environment. The study's findings can be a great resource for architects, interior designers and developers looking to construct homes that promote human enjoyment and environmental responsibility.

4.4. Limitations and future research directions

The scope of this study is restricted to the field of interior architecture. Future studies are advised to look into the literature on industrial and product design, biodesign, biomaterials, bioinspired design, biomimicry or other pertinent viewpoints. Researchers would be able to look into how experts in these fields have produced furniture, other elements that can be directly applied to interior design products and successful biophilic design products. Despite the useful insights gathered from this study on improving user experience in interior architecture through biophilic design in urban residential spaces, several limitations should be noted. To begin, the sample was constrained to a specific geographic region and a specific set of criteria, which may limit the findings' generalizability to other situations. To further corroborate the findings, future research should seek to repeat this study in multiple areas and with varied participant groups.

Another issue is the dependence on residents' self-reported data. While self-reports give useful subjective viewpoints, they are susceptible to biases and subjective interpretations. Objective metrics, such as physiological reactions or behavioral observations, might be used in future studies to supplement self-reported data and give a more full knowledge of the user experience.

This study also focused on biophilic design components and their influence on user experience. Other elements, such as the inhabitants' socioeconomic situation, cultural background and personal tastes, may, nevertheless, impact their experience of interior architecture. Future research might look at the interaction between biophilic design and these environmental elements to offer a more complete picture.

Furthermore, the study notes that the individuals' educational backgrounds and experiences may be similar, which may influence the diversity and depth of replies acquired via the questionnaire. The uniformity of educational contexts might result in a lack of diverse views, thereby limiting the breadth of insights and ideas offered by the data. The study does, however, take measures to offset this restriction by guaranteeing a varied sample of individuals from various demographic backgrounds and use rigorous data analysis approaches to derive significant conclusions. Despite this limitation, the study recognizes the significance of understanding the user experience in interior architecture and seeks to provide valuable insights into the application of biophilic design principles in urban residential spaces, ultimately contributing to the enhancement of user experience and well-being in these environments.

Finally, this study concentrated mostly on residential areas. The findings may not fully represent the complexity and subtleties of biophilic design in other indoor contexts, such as workplaces, healthcare facilities, or educational institutions. Future study should

look at the use of biophilic design concepts in these various environments and the effects they have on user experience and well-being. This study focused on the immediate benefits of biophilic design on user experience. Long-term benefits, such as the sustainability and maintenance of biophilic elements, as well as the longevity of favorable effects on inhabitants, are essential subjects for future research.

In conclusion, while this study gives useful insights into improving user experience in urban residential environments through biophilic design, it is critical to recognize the limitations and address them in future research. Future research can contribute to our understanding of the role and potential of biophilic design in creating supportive and enriching interior environments by broadening the scope, considering diverse contexts and participant groups, incorporating objective measures and investigating the interplay with contextual factors.

5. Conclusion

5.1. Summary of key findings

On February 6, 2023, Turkey witnessed a severe earthquake, which caused a shift in the afflicted population's housing choices. After the Covid-19 Pandemic, the earthquake caused many people to migrate from high-rise buildings to single-story villa-style homes. This shift in home preferences might be linked to a variety of variables. For starters, because of their height and structural complexity, high-rise structures are sometimes considered as more vulnerable to seismic activity, raising worries about safety and stability. The earthquake most certainly heightened these fears and drove people to look for better and more robust housing solutions. Second, because people have direct access to the outdoors and may readily evacuate the structure in the case of an emergency, single-story villa-style buildings provide a sense of security and control. Furthermore, villa-style houses are often built on smaller pieces of land, providing for more privacy and control over one's immediate surroundings. This shift from high-rise structures to single-story villas marks a dramatic shift in the housing scene, as people emphasize safety and security in the aftermath of the earthquake. The shift emphasizes the influence of natural catastrophes on housing choices, as well as the need of resilience and adaptation in urban design and architecture.

The issue of biophilia has caught the attention and curiosity of everyone participating in this investigation. The notion of biophilia, which investigates the natural connection and affinity between humans and nature, has gained importance and has become a topic of debate. Researchers, architects, designers and people from all walks of life are intrigued to the concept of biophilia and its possible implications for human well-being and the built environment. There is a widespread belief that incorporating natural components, patterns and processes into our environment may improve our physical, emotional and psychological well-being. The broad interest in biophilia reflects a rising awareness of the value of nature in our lives, as well as a communal yearning to reconnect with our natural surroundings.

As a result of interviews with focus groups the significance of tangible interior products was one of the main conclusions. Interior products' physical presence has proven to be important in the context of biophilic design, which aims to create spaces that improve users' well-being and connect them with nature. A tangible and sensory connection to nature was provided by tangible products, such as functional items, decorative elements and furniture colors. The tangibility of these interior spaces

contributed to the users' more genuine and immersive experience. Put another way, a major factor in the success of biophilic design in enhancing the user experience was the physicality of the products.

The study also stressed how important it is for these interior products to be easily mobile within the living areas. Because these products were movable and reconfigurable, users were able to interact dynamically with their surroundings. This mobility was in line with the ideas of biophilic design, which frequently aims to emulate the dynamic, ever-changing elements of the natural world. Users' sense of control and connection to the environment would be enhanced if they could move these products to suit their changing needs, moods or preferences in their living areas. The study also discovered that tangibility and mobility are two qualities that interior products should have in order to improve user experience in urban residential spaces within the framework of biophilic design. These characteristics guarantee a more authentic and active relationship with the natural world, which enhances residents' happiness and well-being.

These findings causesed perceptions of biophilic design features in residential settings, emphasizing the importance of economic differences and gender in determining people's attitudes and preferences toward biophilic design.

5.2. Implications of the study

The study has a number of ramifications. For starters, the findings of the similarities in socio-demographic factors across male and female participants imply that biophilic design interventions can be applied in residential areas without major gender differences. This means that designers and architects might explore using gender-neutral biophilic design components to improve user experience. Second, the higher average scores among male participants in perceiving biophilic design components, as well as their positive emotional responses, show the need of taking gender variations in design preferences and experiences into account. Designers should strive to create inclusive and engaging places that cater to both male and female residents' various requirements and preferences. Furthermore, income-based comparisons show that people with greater incomes appreciate and perceive the benefits of biophilic design more favourably. This shows that the price and availability of biophilic design interventions may have an impact on overall user experience and well-being. Designers, politicians and developers should think about ways to make biophilic design more accessible and inexpensive to people of all economic levels. Overall, the study stresses the necessity of taking socio-demographic aspects like gender and income into account when implementing and promoting biophilic design in urban residential settings in order to improve user experience and well-being.

5.3. Recommendations for future research and dwelling designers

These suggestions are intended to improve the integration of biophilic design concepts and the overall user experience in residential settings.

Future Suggestions for Research:

- Examine the effects indoor plants have on the quality of the air. This could entail calculating and examining the precise air contaminants that indoor plants are best at eliminating or lowering in interior settings.
- Consider the possible health advantages of indoor plants, particularly regarding allergies and respiratory conditions. Research may examine elements including lung function, respiratory symptoms and allergic reactions, as well as the frequency

and severity of respiratory disorders in environments with and without indoor plants.

- Examine the underlying mechanisms that underlie the connection between indoor plants, health and air quality. Understanding how indoor plants interact with bacteria, release helpful compounds or eliminate toxins could be the focus of this research.
- With this understanding, indoor plants could be used more effectively to improve air quality and support improved health outcomes.

Realistic Suggestions for Designers:

- Stress the use of natural materials like wood and stone, indoor plants and natural light sources while designing interior spaces. This results in situations that are aesthetically beautiful and psychologically stimulating, encouraging rest and wellbeing.
- Think about how dwellings are organized and arranged in terms of space. Create open, versatile floor plans that make it simple to move about and communicate with people in different regions. Establish distinct areas for rest, work and socializing to accommodate the varying requirements and inclinations of the occupants.
- Include environmentally friendly and sustainable elements in the design of your house, such as recycled building materials and energy-efficient appliances.
- Make sustainability a top priority to lessen residential areas' negative environmental effects and promote eco-friendly living.
- Emphasize how crucial it is for users to engage and interact with the design process at every stage. Incorporate residents into the decision-making process and provide them with personalization and customization options to strengthen their bond with their living area and increase their level of satisfaction with the overall design.

These recommendations seek to improve the way biophilic design ideas are integrated with the entire user experience in residential environments, offering designers useful direction for their work as well as potential research avenues.

Figure 3. Outlining the recommendations for dwelling designers based on the study (Author 2023).

Finally, based on the research findings and consequences, the paper makes various suggestions for home designers. Designers may improve the user experience and create residential settings that encourage well-being, contentment and environmental concern by applying biophilic design concepts, designing practical spatial layouts, emphasizing sustainability and including users in the design process. These guidelines are useful for designers who want to maximize the design of urban residential homes.

References

Ahmed, A.N., Shukur, S.M. (2022). Biophilic design patterns implementation in houses: A case study of residential villages in Erbil city. *Eurasian Journal of Science & Engineering, 8*(1), 1. https://doi.org/10.23918/eajse.v8i1p1

Allen, J.G., MacNaughton, P., Satish, U., Santanam, S., Vallarino, J. & Spengler, J.D. (2017). Associations of cognitive function scores with carbon dioxide, ventilation, and volatile organic compound exposures in office workers: A controlled exposure study of green and conventional office environments. *Environmental Health Perspectives, 125*(9), 097015.

Andreucci, M.B., Loder, A., Brown, M. & Brajković, J. (2021). Exploring challenges and opportunities of biophilic urban design: Evidence from research and experimentation. *Sustainability, 13*(8), 4323. https://doi.org/10.3390/su13084323

Annerstedt, M., Jönsson, P., Wallergård, M., Johansson, G., Karlson, B., Grahn, P. & Hansen, Å.M. (2013). Inducing physiological stress recovery with sounds of nature in a virtual reality forest–results from a pilot study. *Physiology & Behavior*, 118, 240-250.

Bajçinovci, B.Q. (2019). Biomimicry and biophilic design: Multiple architectural precepts. *Journal of Science, Humanities and Arts, 6*(3). https://doi.org/10.17160/josha.6.3.544

Barbiero, G., Berto, R. (2021). Biophilia as Evolutionary Adaptation: An Onto- and Phylogenetic Framework for Biophilic Design. *Frontiers in Psychology*, 12, Article 700709. https://doi.org/10.3389/fpsyg.2021.700709

Barrett, P., Zhang, Y. (2010). Optimum learning environments: A case study of two primary schools in Sydney, Australia. *Learning Environments Research, 13*(2), 107-122.

Bolten, B., Barbiero, G. (2020). Biophilic design: How to enhance physical and psychological health and wellbeing in our built environments. *Visions for Sustainability*, 13. https://doi.org/10.13135/2384-8677/3829

Browning, W.D., Ryan, C.O. & Clancy, J.O. (2014). *14 Patterns of Biophilic Design: Improving Health and Well-Being in the Built Environmen*t. New York: Terrapin Bright Green.

Browning, W.D., Ryan, C.O. (2020). Biophilic design. In *Sustainable Built Environments*, 43-85. Springer.

Browning, W.D., Ryan, C.O. (2020). *Nature Inside: A Biophilic Design Guide*. Routledge.

Dalay, L. (2020). The impact of biophilic design elements on the atmospheric perception of the interior space. *Uluslararası Peyzaj Mimarlığı Araştırmaları Dergisi (IJLAR) 4*(2), 4-20. Istanbul Technical University, Faculty of Architecture, Department of Landscape Architecture.

Dalay, L., Aytaç, G. (2022). Biophilic design: Integrating nature into the urban environment. In *Emerging Approaches in Design and New Connections with Nature*.

Devlin-Scherer, R., Kuo, F.E. & Sullivan, W.C. (2018). Building supportive spaces for children with autism spectrum disorder in a nature-based preschool. *Journal of Architectural and Planning Research, 35*(2), 147-160.

Elnaggar, H. (2023). Influence of modern design trends in interior architecture studio biophilic design styles in office space. مجلة العمارة و الفنون و العلوم الإنسانية, 8(38), 96-115.

Fjeld, T., Veitch, J.A. & Gauthier, N. (2016). Impact of windows and daylight exposure on overall health and sleep quality of office workers: A case-control pilot study. *Journal Of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine, 12*(03), 351-356.

Gaekwad, J.S., Sal Moslehian, A., Roös, P.B. & Walker, A. (2022). A meta-analysis of emotional evidence for the biophilia hypothesis and implications for biophilic design. *Frontiers in Psychology*, 13. https://doi.org/10.3389/fpsyg.2022.750245

Ghaziani, R., Lemon, M. & Atmodiwirjo, P. (2021). Biophilic design patterns for primary schools. *Sustainability*, *13*(21), 12207. https://doi.org/10.3390/su132112207

Gillis, K., Gatersleben, B. (2015). A review of psychological literature on the health and wellbeing benefits of biophilic design. *Buildings*, *5*(3), 948-963. https://doi.org/10.3390/buildings5030948

Hidayati, A., Lukman, M., Yulianti, L. & Marzuki, M. (2019). Biophilic design for indoor learning spaces: Reviewing the effects on student's physiological and psychological responses. *Journal of Physics: Conference Series*, *1157*(3), 032037.

Hudson, K.P.C. (2013). Holistic Dwelling: Integrating Biophilic Design, Environmental Psychology and Feng Shui. Doctoral dissertation, School of Architecture, University of Hawai'i.

Hung, S.H., Chang, C.Y. (2021). Health benefits of evidence-based biophilic-designed environments: A review. *Journal of People Plants Environment*, *24(*1), 1-16. https://doi.org/10.11628/ksppe.2021.24.1.1

Hung, S.H., Chang, C.Y. (2022). How do humans value urban nature? Developing the Perceived Biophilic Design Scale (PBDs) for preference and emotion. *Urban Forestry & Urban Greening*, 76, 127730. https://doi.org/10.1016/j.ufug.2022.127730

Kanwal, N., Awan, U. (2020, October 29). *Role of Design Thinking and Biomimicry in Leveraging Sustainable Innovation*. Springer, Cham. https://doi.org/10.1007/978-3-319-71059-4_86-1

Kellert, S.R. (2008). *Building for Life: Designing and Understanding the Human-Nature Connection*. Island Press.

Kellert, S.R. (2018). *Nature by Design: The Practice of Biophilic Design*. Yale University Press.

Kellert, S.R., Calabrese, E.F. & Kellert, S.R. (2015). The practice of biophilic design. *Terrapin Bright LLC*, *3*(21). London.

Kellert, S.R., Heerwagen, J. & Mador, M. (2011). *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life*. John Wiley & Sons.

Largo-Wight, E., Chen, W.W., Dodd, V. & Weiler, R. (2011). Healthy workplaces: The effects of nature contact at work on employee stress and health. *Public Health Reports*, *126* (Suppl 1), 124-130.

Lee, E.J., Park, S.J. (2021). Toward the biophilic residential regeneration for the green new deal. *International Journal of Environmental Research and Public Health*, *18*(5), 2523. https://doi.org/10.3390/ijerph18052523

Lee, E.J., Park, S.J. (2022). Biophilic experience-based residential hybrid framework. *International Journal of Environmental Research and Public Health*, *19*(14), 8512. https://doi.org/10.3390/ijerph19148512

Lee, S.H. (2019). Effects of biophilic design on consumer responses in the lodging industry. *International Journal of Hospitality Management*, 83, 141-150. https://doi.org/10.1016/j.ijhm.2019.05.006

Lee, S.H., Tao, C.W. & Oh, H. (2022). All that glitters is not green: Impact of biophilic designs on customer experiential values. *Journal of Hospitality & Tourism Research, 47*(4), 18-32. https://doi.org/10.1177/10963480221134

Lei, Q., Yuan, C. & Lau, S.S.Y. (2021). A quantitative study for indoor workplace biophilic design to improve health and productivity performance. *Journal of Cleaner Production*, 324, 129168. https://doi.org/10.1016/j.jclepro.2021.129168

Maharani, R.T., Fitriyanto, D.A. (2022). Biophilic design to enhance residence comfort in COVID era. *Journal of Architectural and Engineering Research*, 2, 41-51. Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya, Indonesia. Retrieved from https://doi.org/10.54338/27382656-2022.2-007

Marte, E., Calumpit, A., de Sá Bessa, B., Toledo, A., Fadda, R. & Skoler, T. (2020). Testing reliability of biophilic design matrix within urban residential playrooms. *Frontiers in Psychology*, 11. https://doi.org/10.3389/fpsyg.2020.570099

Miller, E., Osborne Burton, L. (2023). Redesigning aged care with a biophilic lens: A call to action. *Cities & Health*, *7*(2), 260-272. https://doi.org/10.1080/23748834.2020.1772557

Mohammed, A.B. (2023). A progressive checklist to create design solutions in buildings through biophilia design post-coronavirus. *Engineering Journal*, *2*(2). https://msaeng.journals.ekb.eg/10.21608/MSAENG.2023.291912

Mollazadeh, M., Zhu, Y. (2021). Application of virtual environments for biophilic design: A critical review. *Buildings*, *11*(4), 148. https://doi.org/10.3390/buildings11040148

Moslehian, A.S., Roös, P.B., Gaekwad, J.S. & Van Galen, L. (2023). Potential risks and beneficial impacts of using indoor plants in the biophilic design of healthcare facilities: A scoping review. *Building and Environment*, 233, 110057. https://doi.org/10.1016/j.buildenv.2023.110057

Nitu, M.A., Gocer, O., Wijesooriya, N., Vijapur, D. & Candido, C. (2022). A biophilic design approach for improved energy performance in retrofitting residential projects. *Sustainability*, *14*(7), 3776. https://doi.org/10.3390/su14073776

Park, S.A., Lee, B.R. & Lee, K.E. (2016). Physiological and psychological effects of forest therapy on middle-aged females. *International Journal of Environmental Research and Public Health*, *13*(3), 255.

Peters, T., D'Penna, K. (2020). Biophilic design for restorative university learning environments: A critical review of literature and design recommendations. *Sustainability*, *12*(17), 7064. https://doi.org/10.3390/su12177064

Peters, T., Verderber, S. (2022). Biophilic design strategies in long-term residential care environments for persons with dementia. *Journal of Aging and Environment*, *36*(3), 227-255. https://doi.org/10.1080/26892618.2021.1918815

Richardson, M., Butler, C.W. (2022). Nature connectedness and biophilic design. *Building Research & Information*, *50*(1-2), 36-42. https://doi.org/10.1080/09613218.2021.2006594

Russo, A., Andreucci, M.B. (2023). Raising healthy children: Promoting the multiple benefits of green open spaces through biophilic design. *Sustainability*, *15*(3), 1982. https://doi.org/10.3390/su15031982

Ryan, C.O., Browning, W.D. (2020). Biophilic Design. In Sustainable Built Environments (pp. 43–85). *Encyclopedia of Sustainability Science and Technology Series*. https://doi.org/10.1007/978-1-4939-1519-5_186

Ryan, C.O., Browning, W.D., Clancy, J.O., Andrews, S.L. & Kallianpurkar, N.B. (2014). Biophilic design patterns: Emerging nature-based parameters for health and well-being in the built environment. *International Journal of Architectural Research*, *8*(2), 62-76.

Ryan, C.O., Browning, W.D., Clancy, J.O., Andrews, S.L. & Kallianpurkar, N.B. (2020). Biophilic design patterns: Emerging nature-based parameters for health and well-being in the built environment. *Sustainable Built Environments*, 43-85. Springer.

Sal Moslehian, A., Roös, P.B., Gaekwad, J.S. & Van Galen, L. (2023). Potential risks and beneficial impacts of using indoor plants in the biophilic design of healthcare facilities: A scoping review. *Building and Environment*, 233, 110057.

Sayuti, A.A., Khalaf, O.A. (2019). Nurturing biophilic design and nature-inspired design in furniture design projects. *International Journal of Advanced Science and Technology*, *28*(13), 483-497.

Sayuti, N.A., Sommer, B. & Ahmed-Kristensen, S. (2021). Bio-related design genres: A survey on familiarity and potential applications. In *International Conference on ArtsIT, Interactivity and Game Creation*, 379–393.

Sayuti, N.A.A., Sommer, B. & Ahmed-Kristensen, S. (2020). Identifying the purposes of biological materials in everyday designs. *Environment-Behaviour Proceedings Journal*, *5*(15), 29-37.

Sayuti, N.A.A., Sommer, B. & Ahmed-Kristensen, S. (2022). Biomaterials in everyday design: Understanding perceptions of designers and non-designers. *Proceedings of the Design Society*, 2, 2025-2034.

Shakhshir, K., Sheta, W. (2023). The assessment of biophilic features in residential buildings: A case from Dubai. *Archnet-IJAR*. Retrieved from https://www.archnet-ijar.net/article/assessment-biophilic-features-residential-buildings-case-dubai

Söderlund, J. (2019). *The Emergence of Biophilic Design*. Publisher.

Song, C., Ali, F., Cobanoglu, C., Nanu, L. & Lee, S.H.J. (2022). The effect of biophilic design on customers' subjective well-being in hotel lobbies. *Journal of Hospitality and Tourism Management*, 52, 264-274. https://doi.org/10.1016/j.jhtm.2022.07.008

Totaforti, S. (2020). Emerging biophilic urbanism: The value of the human–nature relationship in the urban space. *Sustainability*, *12*(13), 5487. https://doi.org/10.3390/su12135487

Wijesooriya, N., Brambilla, A. (2021). Bridging biophilic design and environmentally sustainable design: A critical review. *Journal of Cleaner Production*, 283, 124591. https://doi.org/10.1016/j.jclepro.2020.124591

Xue, F., Gou, Z., Lau, S.S.Y., Lau, S.K., Chung, K.H. & Zhang, J. (2019). From biophilic design to biophilic urbanism: Stakeholders' perspectives. *Journal of Cleaner Production*, 211, 1444-1452. https://doi.org/10.1016/j.jclepro.2018.11.277

Zhao, Y., Zhan, Q. & Xu, T. (2022). Biophilic design as an important bridge for sustainable interaction between humans and the environment: Based on practice in chinese healthcare space. *Modeling, Analysis, and Simulations in Mathematical Biology*, 2022(Article ID 8184534). https://doi.org/10.1155/2022/8184534

Zhong, W., Schröder, T. & Bekkering, J. (2022). Biophilic design in architecture and its contributions to health, well-being and sustainability: A critical review. *Frontiers of Architectural Research*, *11*(1), 114-141. https://doi.org/10.1016/j.foar.2021.07.006