ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Research Article *Araştırma Makalesi* DOI: 10.54864/planarch.1491955

Integrating Nature into Academic Spaces: Biophilic Campus

Doğayı Akademik Mekanlara Entegre Etmek: Biyofilik Kampüs

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ABSTRACT

Biophilic design is an architectural approach that fosters connections between humans and nature. The primary objective of this approach is to bridge the gap between the built environment and nature, thereby enhancing the quality of spaces and increasing users' productivity. This study examines integrating biophilic design into campuses categorised according to Linde's university campus layout classifications (diffusive, central, molecular, gridiron, cross, and linear). In this context, the main campuses of Eskişehir Osmangazi University, Tokat Gaziosmanpaşa University, Anadolu University, Istanbul Technical University, Dokuz Eylul University, and Istanbul University were selected as sample areas for analysis. The sample areas were evaluated and compared according to William Browning et al.'s fourteen biophilic design principles based on observation, which is a qualitative research design. The evaluation revealed deficiencies in the window glazing areas of campus buildings, the design of open and semi-open spaces, the use of water and plants in interior spaces, and the integration of water elements into the design. To address these deficiencies, the study recommends that universities prioritise applying biophilic design principles in their physical environment planning. Additionally, various recommendations for implementing these design principles were developed. Implementing these recommendations is expected to facilitate stronger connections between individuals and nature, promoting a more sustainable relationship within built environments.

Keywords: Biophilic design, campus, nature-human, sustainability.

ÖZ

Biyofilik tasarım, insanlar ve doğa arasındaki bağlantıları teşvik eden bir mimari yaklaşımdır. Bu yaklaşımın temel amacı, yapılı çevre ile doğa arasında köprü kurarak mekânların kalitesini ve kullanıcıların üretkenliğini artırmaktır. Bu çalışma, biyofilik tasarımın Linde'nin üniversite kampüs yerleşimi sınıflandırmalarına (yaygın, merkezi, moleküler, ızgara, haç biçimli ve doğrusal) göre kategorize edilen kampüslere entegre edilmesini incelemektedir. Bu bağlamda, Eskişehir Osmangazi Üniversitesi, Tokat Gaziosmanpaşa Üniversitesi, Anadolu Üniversitesi, İstanbul Teknik Üniversitesi, Dokuz Eylül Üniversitesi ve İstanbul Üniversitesi'nin ana kampüsleri analiz için örneklem alanlar olarak seçilmiştir. Örneklem alanlarında nitel bir araştırma deseni olan gözleme dayalı William Browning ve arkadaşlarının on dört biyofilik tasarım ilkesine göre değerlendirilmiş ve karşılaştırılmıştır. Değerlendirme sonucunda kampüs binalarının pencere cam yüzey alanları, açık ve yarı açık alanların tasarımı, iç mekânlarda su ve bitki kullanımı ve su öğelerinin tasarıma entegrasyonu konularında eksiklikler tespit edilmiştir. Çalışma, bu eksikliklerin giderilmesi için üniversitelerin fiziksel çevre planlamalarında biyofilik tasarım ilkelerini uygulamaya öncelik vermelerini önermektedir. Ayrıca, bu tasarım ilkelerinin uygulanmasına yönelik çeşitli öneriler geliştirilmiştir. Bu önerilerin uygulanmasının, bireyler ve doğa arasında daha güçlü bağlar kurulmasını kolaylaştırması ve yapılı çevrelerde daha sürdürülebilir bir ilişkiyi teşvik etmesi beklenmektedir.

Anahtar Kelimeler: Biyofilik Tasarım, kampüs, doğa-insan, sürdürülebilirlik.

Received / Geliş Tarihi 29.05.2024
Revision Requested / Revizyon Talebi 15.07.2024
Last Revision / Son Revizyon 20.08.2024
Accepted / Kabul Tarihi 23.08.2024
Publication Date / Yayın Tarihi 15.09.2024

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Cite this article: Özdemir, H. (2024). Integrating Nature into Academic Spaces: Biophilic Campus. *PLANARCH - Design and Planning Research*, 8(2), 210-224. DOI: 10.54864/planarch.1491955

Introduction

The relationship between humans and nature is becoming increasingly significant in the contemporary era. The rapid advancement of technology and urbanisation, which has led to the creation of concrete jungles, has resulted in a distance between people and the natural environment, limiting their experiences of nature's benefits. However, in recent years, there has been a growing interest in research into close contact with nature, which has led to a more thorough examination of the positive effects of nature on human health and well-being. The findings of these studies indicate that environments incorporating biophilic design principles can positively impact mental and physical health and productivity (Kellert et al., 2011).

Biophilic design incorporates natural features into interiors or buildings (Beatley, 2011), using elements like colours, textures, patterns, light, and sound to recreate natural environments. This approach fosters a connection with nature. Research shows that biophilic design can enhance visual attention in adults and children (Fadda et al., 2023) and improve productivity in office settings (Gao et al., 2023).

Biophilic design principles encompass a range of factors that facilitate a deep connection between individuals and nature. These principles include the visual aspects of nature and potential non-visual connections that can be established. Additionally, integrating dynamic and diffused light is considered necessary in this design approach. By combining these elements, designers aim to create environments that support positive cognitive effects and influence the functioning of the autonomic nervous system, brain activation patterns, and design quality (Madias et al., 2023). The importance of biophilic design lies in bridging the gap between built environments and nature, thereby promoting healing, productivity, and rejuvenation within built environments (Mohammed, 2023). This approach, emphasising individual well-being and sustainability, has been applied across various fields, including architecture.

As applied in architecture, biophilic design places immense importance on integrating natural elements into the built environment to enhance human health and well-being. It acknowledges the significant role of nature in design and aims to create spaces that positively affect individuals, encompassing physical, psychological, and intellectual dimensions (Gautam, 2017). This design approach establishes a profound connection between people and nature through many elements, including gardens, green landscapes, natural light, and architecture inspired by nature (Chawla, 2012). In particular, implementing biophilic design has yielded significant mental health benefits in healthcare service environments, such as children's hospitals, where it has been demonstrated to enhance patient well-being and recovery rates (Sabaa et al., 2022). Furthermore, by considering individuals' physiological and psychological needs and creating environmentally sustainable living spaces, this design approach promotes sustainability in architecture (Nota et al., 2017). Biophilic design is widely accepted to have the potential to alleviate psychological problems associated with built environments and enhance overall quality of life. Promoting cognitive function, reducing stress, and providing a sense of mental tranquillity offers a comprehensive solution to challenges encountered in architecture (Asim et al., 2021).

Academic spaces, crucial for education and research, often lack vitality due to limited natural light and elements. Applying biophilic design strategies offers a significant opportunity to enrich these environments and improve the learning and research experience.

This scientific exhibition explores how biophilic design strategies transform academic spaces and identifies critical components for developing biophilic campuses. The study will first define and outline the principles of biophilic design. It will then discuss the benefits of integrating these principles into academic environments and identify specific areas within institutions where they can be applied. Additionally, the exhibition will address critical factors for shaping biophilic campuses.

This study aims to guide integrating biophilic design principles into academic spaces, providing actionable recommendations for creating biophilic campuses. It is expected to enhance the health and well-being of students, academics, and staff while supporting educational and research goals and advancing sustainability. Increased research and application in this field are anticipated in the future.

Theoretical Background

Biophilic design is an approach that integrates natural elements and nature-inspired principles into built environments, recognising the intrinsic connection between humans and nature. Rooted in "biophilia," meaning a deep love for life, this concept highlights the profound impact of natural environments on human well-being and health.

The roots of biophilic design can be traced back to the 1980s, extending until Edward O. Wilson's groundbreaking work "Biology and Human Nature," published in 1984. Biologist Wilson (1984) proposed the biophilia hypothesis, arguing that it is an innate urge to connect with other life forms. This pioneering contribution played a crucial role in popularising the concept of biophilia and subsequently contributed to the development of biophilic design.

Stephen Kellert (1993) summarises the principles of biophilic design in his work "Nature by Design: The Practice of Biophilia," highlighting core concepts such as direct interaction with nature, use of natural elements, integration of natural light and ventilation, incorporation of natural views, natural sounds and scents, use of natural materials and textures, consideration of locality and uniqueness, promotion of biophilic diversity, and commitment to sustainability. Another notable development occurred when Heschong et al. (1999) published a research report titled "Daylighting in Schools: Examining the Relationship between Daylighting and Human Performance," demonstrating the positive impact of daylight on student achievement. Subsequently, Terrapin Bright Green published a report titled "Fourteen Patterns of Biophilic Design," showcasing concrete examples and case studies demonstrating the practical implementation of biophilic design in various building types (William Browning et al., 2014). Finally, the WELL Building Standard was introduced as a building certification system in 2014, considering the impact of biophilic design on human health and well-being.

Biophilic design principles are currently being applied in various architectural contexts. Comprehensive research has confirmed the positive impact of incorporating biophilic design into offices, schools, hospitals, residences, and other public areas on human well-being and productivity (Gray & Birrell, 2014; Zhong et al., 2022). Biophilic design, evolving through ongoing research, seeks to create healthier, more sustainable environments by strengthening the bond between individuals and nature for harmonious coexistence.

The Fundamental Principles of Biophilic Design

Biophilic design incorporates nature into built environments to improve the human-nature relationship. Kellert (2008) defined 72 criteria in six categories focused on natural elements and interaction, while Kellert and Calabrese (2015) identified 24 features and three experiences to enhance this connection. William Browning et al. (2014) proposed fourteen principles for biophilic design based on insights from psychology, endocrinology, and neuroscience.

Table 1. 14 Patterns of Biophilic Design (William Browning et al., 2014)

NATURE IN THE SPACE	NATURAL ANALOGUES	NATURE OF THE SPACE
1. Visual Connection with Nature A view to elements of nature, living systems and natural processes. **2. Non-Visual Connection with Nature** Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes. **3. Non-Rhythmic Sensory Stimuli** Stochastic and ephemeral connections with nature may be analysed statistically but not precisely predicted. **4. Thermal & Airflow Variability** Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments. **5. Presence of Water** A condition that enhances the experience of a place through the seeing, hearing, or touching of water. **6. Dynamic & Diffuse Light** Leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature. **7. Connection with Natural Systems** Awareness of natural processes and seasonal and temporal changes characteristic of a healthy ecosystem.	**8. Biomorphic Forms & Patterns** Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature. **9. Material Connection with Nature** Material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place. **10. Complexity & Order** Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.	**11. Prospect** An unimpeded view over a distance for surveillance and planning. **12. Refuge** A place for withdrawal from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead. **13. Mystery** More information is promised through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment. **14. Risk/Peril** An identifiable threat coupled with a reliable safeguard.

The principles identified by William Browning et al. (2014) are as follows: The "Visual Connection with Nature" emphasises that users must establish a visual link with the outdoor environment. The "Non-Visual Connection with Nature" aims to create spatial arrangements that give the impression of being part of nature, even without direct visual contact with the outdoors. The "Non-Rhythmic Sensory Stimuli" highlights the importance of design forms that appeal to all five senses. "Thermal & Airflow Variability" incorporates elements that enhance users' thermal comfort. The "Presence of Water" underscores water's inclusion in interior and exterior spaces. "Dynamic & Diffuse Light" stresses the importance of utilising light effects in both indoor and outdoor environments. "Connection with Natural Systems" refers to climate-sensitive design practices specific to the location. The "Biomorphic Forms & Patterns" promotes the integration of biomorphic forms in architecture. "Material Connection with Nature" advocates using materials that evoke or belong to nature. "Complexity & Order" involves creating distinguishable architectural designs systematically. The "Prospect" consists in creating visually noticeable spaces with expansive views. "Refuge" focuses on designing sheltered areas where users can seek safety during potential threats. "Mystery" encourages design approaches that evoke a sense of intrigue and secrecy. Finally, "Risk/Peril" pertains to design strategies that protect users from potential dangers and ensure their safety (Table 1).

The Impact of Biophilic Design on Campus Life

Campuses are dynamic environments where students share knowledge and receive support from faculty members (Museus, Yi, & Saelua, 2017). Green spaces and open walkways enhance campus sustainability and walkability, while higher education institutions focus on sustainability and green initiatives to build a positive brand image (McFarland, Waliczek, & Zajicek, 2008; Ahmed, 2023; Petratos & Damaskou, 2015). Campuses evolve into dynamic environments that significantly shape educational experiences and support learning, research, and well-being (Astawa et al., 2022).

Biophilic design significantly impacts campus environments by improving health, well-being, and productivity. It enhances social engagement, connection to nature, and student interpersonal relationships (Mollazadeh & Zhu, 2021; Alves et al., 2022). Benefits include better physical and psychological well-being, stress reduction, and increased creativity (Jaheen & El-Darwish, 2022; Yin et al., 2019). It also helps manage chronic conditions and fosters sustainable, intelligent campuses that support educational and social needs while integrating environmental sensitivity and technology (Huntsman & Bulaj, 2022). Biophilic design can enhance mental health and boost student productivity. Natural light improves cognitive function, memory, and concentration, which are crucial for academic success (Kaya, 2019). Integrating biophilic elements like natural light, greenery, and natural materials into campus buildings can enhance students' academic performance, sense of community, and connection to nature, ultimately fostering a holistic and enriching educational environment.

Campus Site Typologies

The positioning of universities in expansive areas outside urban centres results from the population's evolving economic, social, cultural, and recreational needs. This shift has led to the concept of "campus-site" and the establishment of universities in remote locations from city centres (Açıksöz, Cengiz, Bekçi, Cengiz, & Gökçe, 2014; Sıramkaya & Çınar, 2012). The term "campus" refers to an educational community encompassing the primary roles of education, teaching, research, and practical application while providing essential living facilities for its residents (Erçevik & Önal, 2011). Campuses serve as versatile compounds hosting various functions, including education, teaching, and residential facilities, requiring a consistent structure to maintain connections between these functions. Therefore, the design of multifunctional campuses must adhere to fundamental principles. The configuration of campus layout typically manifests itself through central, radial, gridiron, cross,

and linear arrangements (Table 2). Each settlement model has advantages and disadvantages, and the unique context of individual campus plans may render one of these layouts more suitable (Begeç, 2002).

Materials and Methods

The study initially conducted a comprehensive literature review on biophilic design and campus typologies, followed by an observational qualitative research methodology (Figure 1). Following the literature review, the study classified university campuses based on Linde's (1971) typology, which organises campuses according to the arrangement of functional areas and campus development into diffusive, central, molecular, gridiron, cross, and linear forms (Table 2).

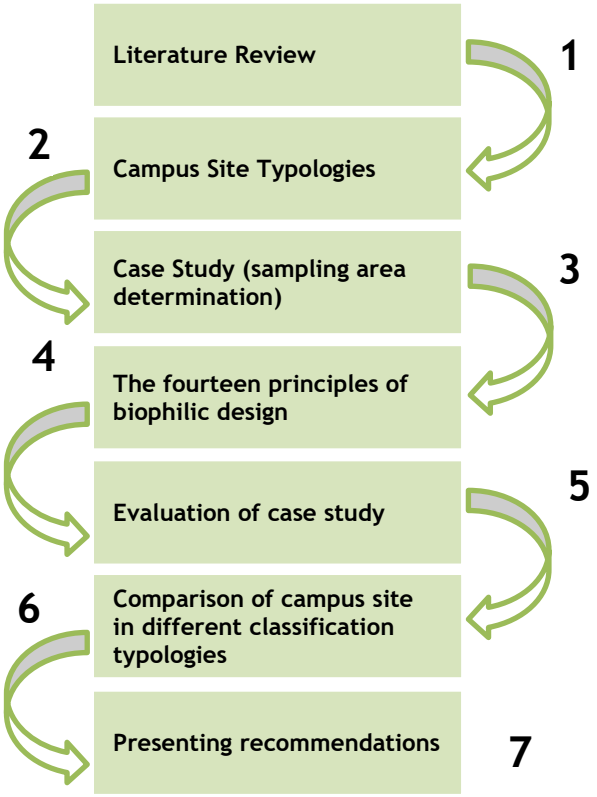


Figure 1. The flow of research methodology

Using Linde's classifications as a foundation, Tokat Gaziosmanpaşa University (TOGU) Taşlıçiftlik Campus was categorised as "diffusive," Anadolu University (AU) Yunus Emre Campus as "central," and Istanbul Technical University (ITU) Ayazağa Campus as "cross." Additionally, Dokuz Eylul University (DEU) Tınaztepe Campus was classified as "linear," Istanbul University (IU) Avcılar Campus as "gridiron," and Eskişehir Osmangazi University (ESOGU) Meşelik Campus as "molecular."

After selecting the sample areas, the campuses were evaluated and compared based on the 14 principles of biophilic design identified by William Browning et al. (2014): Visual Connection with Nature, Non-Visual Connection with Nature, Non-Rhythmic Sensory Stimuli, Thermal & Airflow Variability, Presence of Water, Dynamic & Diffuse Light, Connection with Natural Systems, Biomorphic Forms & Patterns, Material Connection with Nature, Complexity & Order, Prospect, Refuge, Mystery, and Risk/Peril. The evaluation and comparison resulted in design recommendations for biophilic campus design.

Campus Biophilic Design Review Results

This section evaluated ESOGU, TOGU, AU, ITU, DEU, and IU according to the fourteen biophilic design principles identified by William Browning et al. (2014).

ESOGU Meşelik Campus

In the campus layout, the administrative centre is positioned in the south. At the same time, the residential areas are located in the southeast, adhering to a molecular arrangement model where campus functions operate independently (Figure 2).

The evaluation of the Meşelik Campus based on biophilic design criteria indicates significant potential for integrating nature due to the urban forest and the Porsuk River. However, despite the campus's greenery, architectural elements such as large windows and open or semi-open spaces fail to establish a strong connection with nature. Additionally, the need for urban-scale healthcare facilities has led to construction in areas reserved for roads, parking, and green spaces, resulting in higher-than-anticipated density in the health district (Alptekin, Ünver, & Özdemir, 2018).

The extensive use of concrete in campus green areas has significantly reduced natural greenery. Although courtyard designs have been incorporated into the buildings, these spaces lack essential natural elements and sensory engagement; window configurations and light management require optimisation for enhanced environmental interaction.

ESOGU's biophilic design is limited by the absence of site-specific materials and biomorphic patterns, with traditional elements like brick and wood notably missing. While the campus prioritises reinforced concrete for disaster resilience, its design lacks visual connections to the outdoors. Apart from its courtyards, it fails to incorporate elements that evoke a sense of mystery.

TOGU Taşlıçiftlik Campus

A new social and administrative centre has been developed on the eastern side of the campus, around which various faculties, such as those for education, law, engineering, and architecture, have been constructed. In the southeastern area, accommodations have been provided for students, academic staff, and administrative personnel. These arrangements indicate that a diffuse settlement model has been used to design the campus's physical layout (Figure 3).

Table 2. Campus Site Typologies (Dülger, 2017).

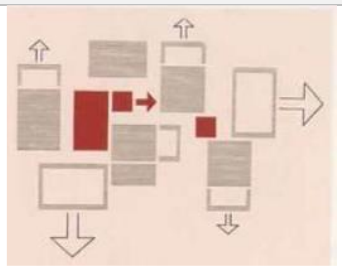
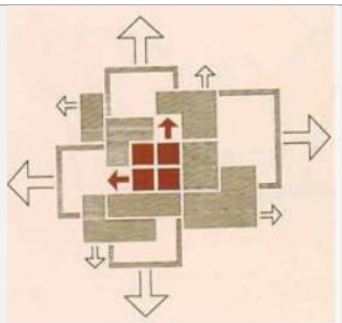
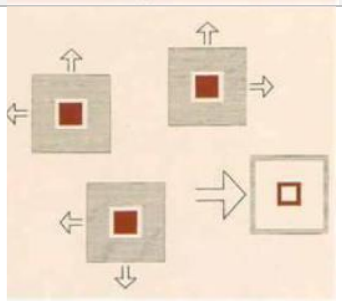
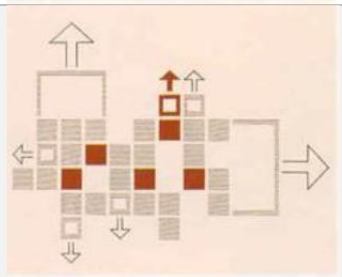
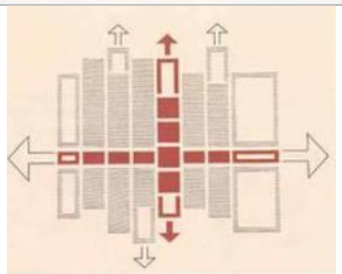
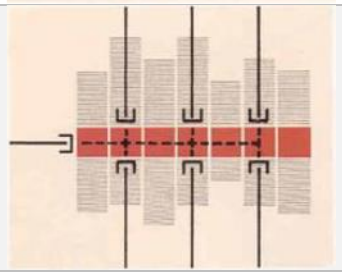
Type	Layout	Description	Advantage	Disadvantage
Diffusive Settlement Model		Diffusive areas are centrally located, with academic and residential areas scattered around them, usually outside urban areas.	Due to the low population density, a second centre might be necessary if the population increases.	Sparse and scattered settlements require extensive space, resulting in high infrastructure costs and transportation challenges.
Centralised Settlement Model		Management and shared spaces are centralised, with academic areas radiating outward and central gaps left for future expansion.	Compact planning facilitates easy inter-unit transportation.	It can accommodate a specific student capacity, but establishing the centre incurs high initial costs.
Molecular Settlement Model		They comprise independent units with shared central facilities, with growth occurring by adding new centres in vacant campus spaces.	The units have high internal densities but low overall campus density.	The transportation system must be well-planned due to the large areas required.
Gridiron Settlement Model		Common areas, housing, and recreational spaces are arranged in a grid around academic buildings.	----------	Overlapping activities lead to structural density, which, if not well-planned, may harm campus integrity and connectivity.
Cross Settlement Model		Academic and communal spaces are arranged in bands along perpendicular axes, with communal spaces extending outward from the centre and academic areas along the opposite axis.	Depending on the campus orientation, one axis connects to the city.	The design process may be lengthy, and central common areas incur high costs.
Linear Settlement Model		The system is arranged along a linear axis, the central transportation route connecting the campus to the city and between units.	It is the most debated yet straightforward layout, with unit developments extending outward along linear axes.	The axis ends are left open for development, with functions arranged in linear bands on both sides, potentially leading to inter-unit transportation issues.

Table 3. Biophilic Design Analysis in Meşelik Campus


Opportunities

	Patterns	Description
Nature in the space	**Visual Connection with Nature**	The limited open spaces and low window-to-wall ratio obstruct visual connections.
	Non-Visual Connection with Nature	Courtyards were integrated but not designed for recreation, limiting visual appeal, and enclosed structures lacked plant or water features, reducing indoor visual impact.
	Non-Rhythmic Sensory Stimuli	The buildings lack elements that engage users' visual, auditory, gustatory, tactile, and olfactory senses.
	Thermal & Airflow Variability	Temperature, humidity, and air quality have not been considered indoors.
	Presence of Water	The branch of the Porsuk River has not been integrated into the campus.
	Dynamic & Diffuse Light	Natural light enters the building, but no facade elements are used to improve thermal comfort.
	Connection with Natural Systems	The campus buildings lack a spatial oasis with plants, soft surfaces, colourful wallpapers, minimalist design, and calming workspaces.
Natural Analogues	**Biomorphic Forms & Patterns**	No biomorphic forms have been observed.
	Material Connection with Nature	Designers did not incorporate regional ecology or omit nature-related elements from the interior.
	Complexity & Order	Design creating a sense of clutter or order has yet to be encountered.
Nature of the space	**Prospect**	The buildings have yet to emphasise the idea of mobility and flexibility.
	Refuge	Measures have been taken against disasters.
	Mystery	The campus lacks designs that evoke a sense of mystery.
	Risk/Peril	No element posing a threat has been observed inside or outside the buildings.

Table 4. Biophilic Design Analysis in Taşlıçiftlik Campus



Opportunities

	Patterns	Description
Nature in the space	**Visual Connection with Nature**	The lack of large windows and semi-open spaces in the buildings hinders the connection with nature.
	Non-Visual Connection with Nature	Architectural skylights address dark spaces in some interiors but disconnect them from their surroundings. Water and plant elements are absent in gallery voids and floor corridors.
	Non-Rhythmic Sensory Stimuli	Some academic buildings have utilised clinker brick coating on their facades, impacting tactile and visual perception.
	Thermal & Airflow Variability	The adequate window openings and climate control systems are evaluated as a positive step in ensuring air circulation within the spaces.
	Presence of Water	The campus has no natural or artificial water feature connecting the spaces.
	Dynamic & Diffuse Light	Natural light for the spaces is provided through windows, but its impact on users' thermal comfort remains unobserved.
	Connection with Natural Systems	The buildings within the campus lack elements such as plants, soft surfaces, colourful wallpapers, and calming workspaces.
Natural Analogues	**Biomorphic Forms & Patterns**	Within the campus buildings, no biomorphic concept has been considered.
	Material Connection with Nature	Buildings have used clinker brick coating on their facades. However, this material is only perceived from the exterior.
	Complexity & Order	Organising buildings around the social centre, academic, and residential units provide order.
Nature of the space	**Prospect**	The buildings have yet to emphasise the idea of freedom, mobility, and flexibility.
	Refuge	The need for shelter has been addressed by considering precautions against natural disasters.
	Mystery	The pathways nestled within the natural greenery of the TOGU evoke a sense of mystery.
	Risk/Peril	No element posing a threat has been observed inside or outside the buildings.

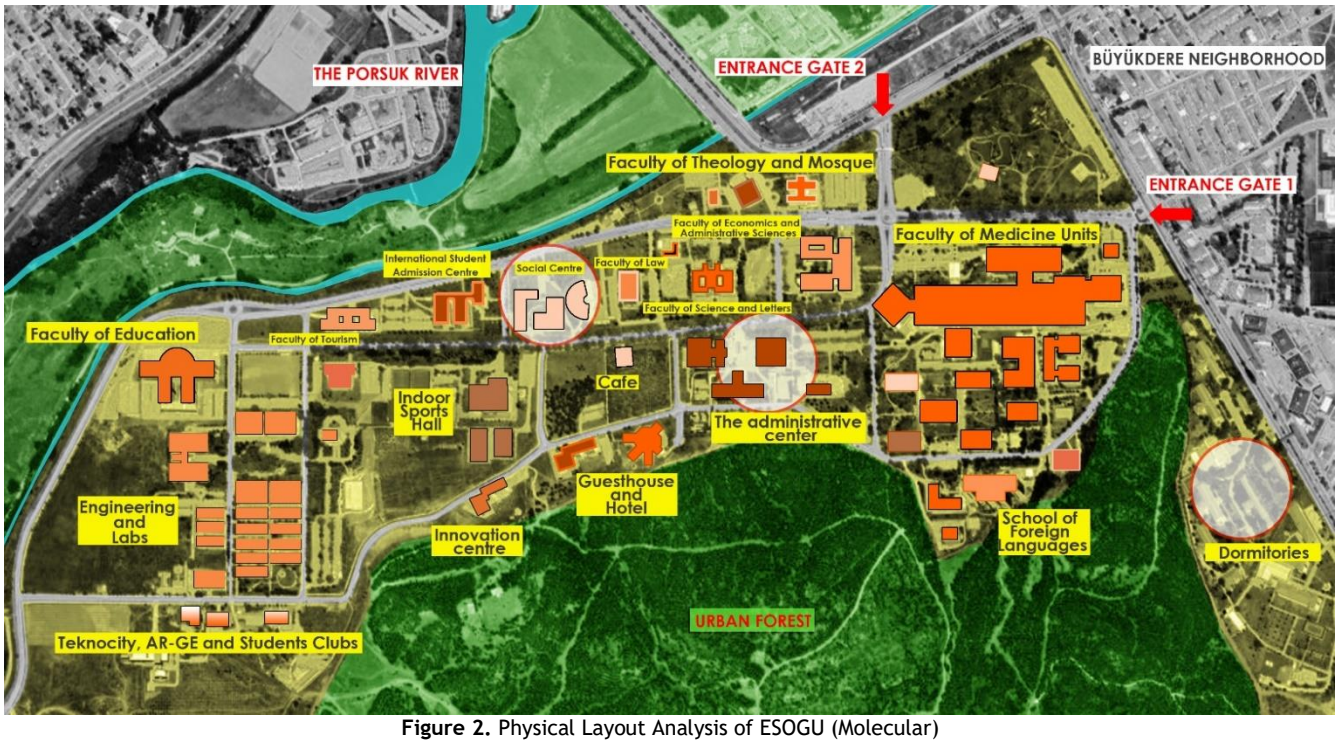


Figure 2. Physical Layout Analysis of ESOGU (Molecular)

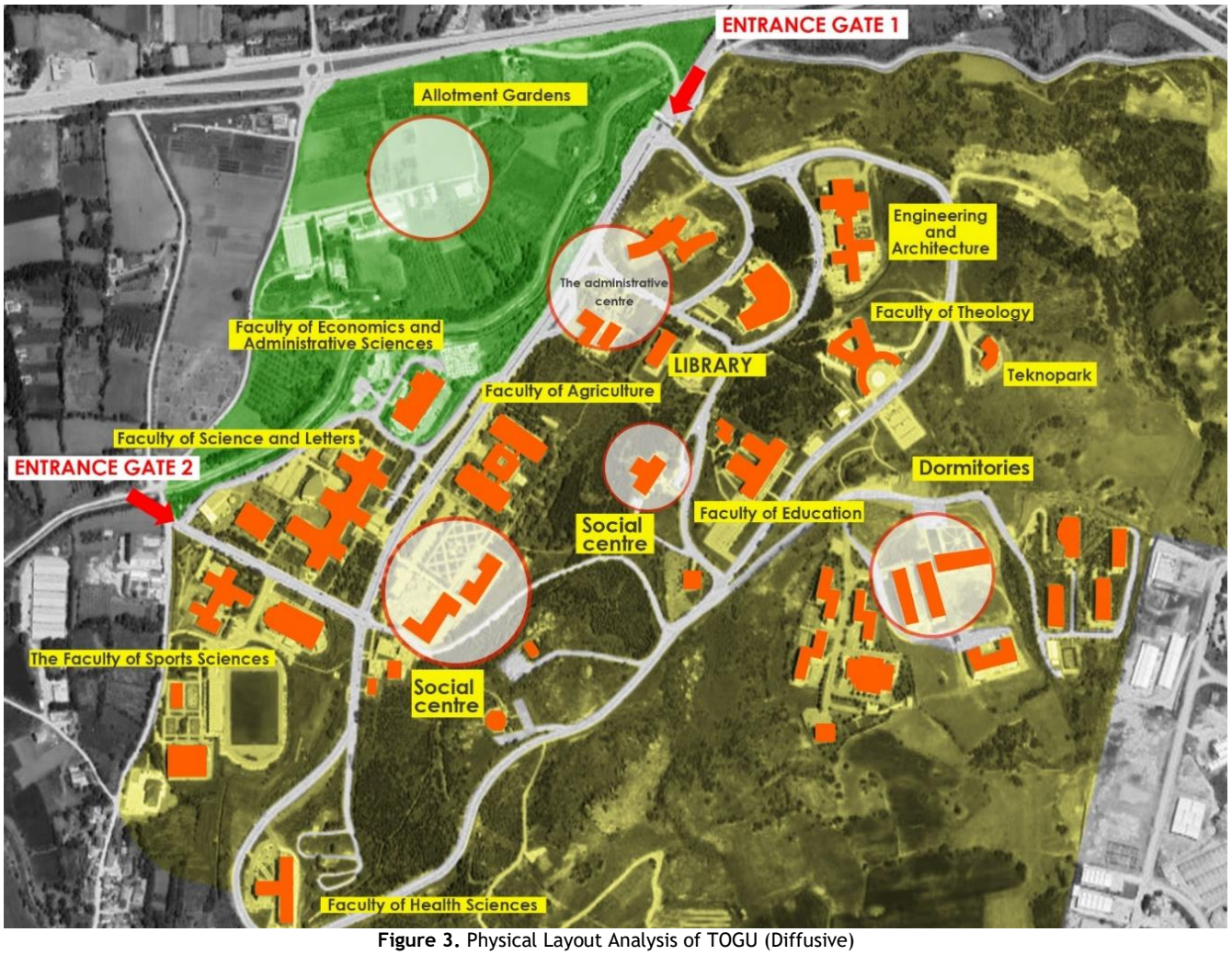


Figure 3. Physical Layout Analysis of TOGU (Diffusive)

The evaluations conducted for the TOGU according to the biophilic design criteria are presented in Table 4. TOGU has significant potential for connecting with nature due to its hobby gardens and natural greenery. However, the absence of large open windows and semi-open spaces in the campus buildings complicates establishing this connection. While there are open spaces, these areas are concentrated around the social centre. Architectural lighting elements have been used in buildings to prevent the formation of dark spaces inside. These spaces have been directly disconnected from the surroundings.

Water elements, pleasant sounds, smells, and botanical features are absent in gallery voids and floor corridors for relaxation and seating. The buildings' facades are clad in clinker brick, which engages tactile and visual senses; however, inconsistent application across buildings has disrupted sensory integrity. Adequate window openings and climate control systems are noted to be positive for air circulation. However, the campus lacks natural or artificial water features to enhance spatial connection. While natural light is introduced through skylights and windows, considerations for optimising thermal comfort by managing light and blocking unwanted infrared radiation are overlooked.

TOGU incorporates urban fabric-specific materials, such as clinker brick facades, which lack biomorphic patterns and have a primarily external impact. The design notably lacks stone and wood elements. Although the arrangement of buildings around social, academic, and residential areas creates a sense of organisation, the expansion of academic units introduces a degree of disorder. Pathways within TOGU's natural greenery evoke a sense of mystery and encourage exploration while necessary precautions are implemented to mitigate potential risks and hazards within the buildings.

AU Yunus Emre Campus

AU in the centre of Eskişehir has been developed using a centralised settlement model (Figure 4). Evaluations of the AU based on biophilic design criteria are shown in Table 5. The AU has significant potential for connecting with nature, primarily through its water channel. However, the link between the water channel and academic units must be more precise. The campus's central city location limits its potential for a broader connection with nature. The buildings within the campus are low-rise, with appropriate glazed surface area of the windows and dining areas establishing a semi-open space relationship. Every academic unit has access to open spaces for interaction, but the dense central area makes these spaces less noticeable. Buildings feature courtyard designs or various plan types (square, rectangular, L-shaped, U-shaped). Additional accommodations for more students have led to challenges in fulfilling indoor functions. Furthermore, the proximity of buildings in the campus centre has resulted in inadequate utilisation of sunlight. Plant elements are used in resting or seating areas of gallery voids and floor corridors but lack water features, pleasant sounds, or scents. Brick material, reflecting Eskişehir's visual and cultural character, is used in campus buildings, appealing to tactile and visual senses. Adequate window openings and climate control systems are positively viewed for air circulation. While a Japanese garden and artificial water feature are on the campus's south side, other areas lack water features.

AU Campus incorporates brick materials that are characteristic of the urban fabric within the natural analogy framework of biophilic design. The buildings do not exhibit biomorphic forms or patterns. The centralised arrangement of administrative and social units fosters a sense of order. Similarly, AU Yunus Emre Campus employs a centralised settlement model, enhancing openness and readability at the expense of mystery. Measures have been implemented to mitigate potential risks and hazards within the buildings.

Table 5. Biophilic Design Analysis in Yunus Emre Campus


Opportunities

	Patterns	Description
Nature in the space	**Visual Connection with Nature**	The buildings are low-rise, with adequate glazed surfaces, establishing a semi-open relationship with dining areas. Nearly every academic unit has access to open spaces.
	Non-Visual Connection with Nature	Although plant elements are used in gallery voids and seating areas, they lack water features, pleasant sounds, or scents.
	Non-Rhythmic Sensory Stimuli	Both interior and exterior facades use locally sourced brick, appealing to tactile and visual senses. However, designs for other senses are lacking.
	Thermal & Airflow Variability	Adequate window openings and climate control systems are positive for ensuring air circulation.
	Presence of Water	The natural water channel does not integrate with the buildings. However, artificial water elements facilitate recreation.
	Dynamic & Diffuse Light	Skylights are incorporated into the buildings, but no design has been observed to block unwanted infrared light.
	Connection with Natural Systems	The buildings within the campus lack elements such as plants and calming workspaces.
Natural Analogues	**Biomorphic Forms & Patterns**	No biomorphic forms have been observed.
	Material Connection with Nature	The buildings incorporate brick material, maintaining the continuity of the local architectural culture. Brick material is perceived from interior and exterior facades, appealing to tactile and visual senses.
	Complexity & Order	Organising academic units around a social and administrative centre creates a sense of order.
Nature of the space	**Prospect**	The buildings have yet to emphasise the idea of mobility and flexibility.
	Refuge	The user's need for shelter has been primarily addressed by considering precautions against natural disasters.
	Mystery	The central layout design of the Campus is structured to be easily navigable and readable rather than mysterious.
	Risk/Peril	No element posing a threat has been observed inside or outside the buildings.

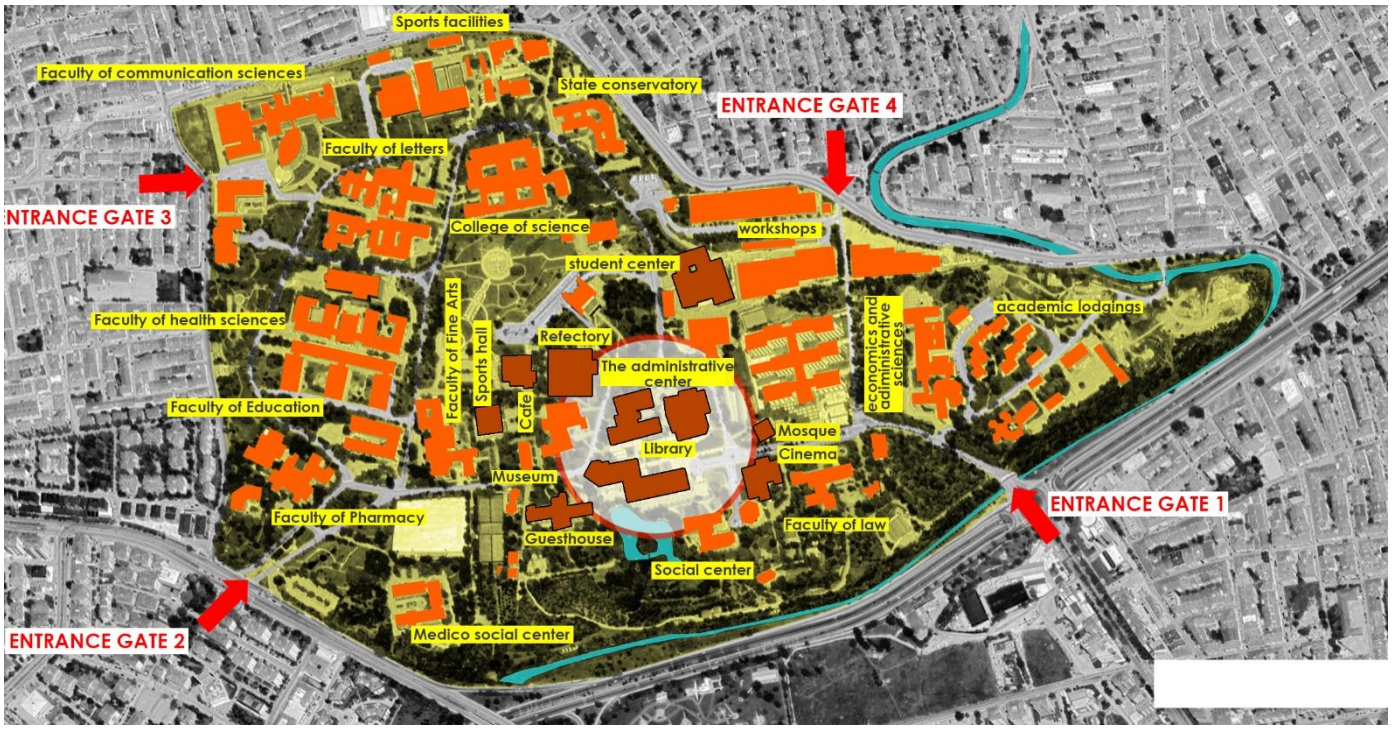


Figure 4. Physical Layout Analysis of AU (Centralized)

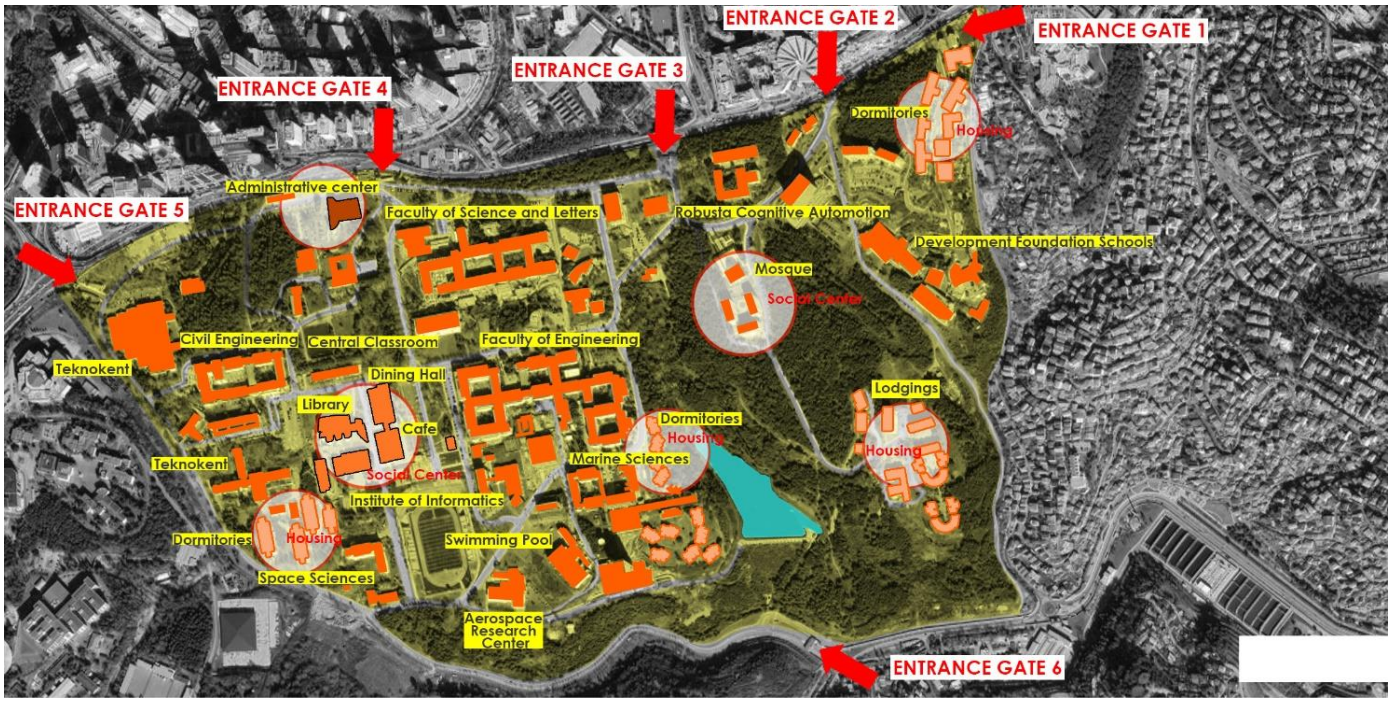


Figure 5. Physical Layout Analysis of ITU (Cross)

ITU Ayazağa Campus

The layout of ITU follows a cross-settlement model, with administrative and academic units extending from southwest to northeast and social and residential units extending from northwest to southeast (Figure 5).

Evaluations of ITU based on biophilic design criteria are summarised in Table 6. The campus's pond and green spaces provide significant nature engagement opportunities. Some buildings, such as the EKO Building Research Centre, foster nature connection, while others, like dormitories, do not. The social centre features large windows and open spaces, enhancing visual connectivity with nature. Campus buildings are arranged in C, U, L, or courtyard shapes, with vegetation in rest and seating areas. However, sensory features like artificial water elements, pleasant sounds, or aromas are absent.

The façades of the buildings on the campus exhibit different design approaches, which do not ensure unity among the buildings. For instance, the façade of the Süleyman Demirel Cultural Centre features a raw concrete effect, appealing to

tactile and visual senses. Adequate window openings and air conditioning systems provide air circulation in the buildings. Except for buildings, artificial water features are absent on the campus. Natural light is provided through the windows, but architectural elements to block unwanted infrared light and enhance thermal comfort for users have not been considered.

Table 6. Biophilic Design Analysis in Ayazağa Campus


Opportunities

	Patterns	Description
Nature in the space	**Visual Connection with Nature**	Most of the buildings within the campus establish a visual connection with nature.
	Non-Visual Connection with Nature	The buildings with C, U, L, or courtyard layouts use plants to connect with nature. However, sensory elements like water features, pleasant sounds, and fragrances are needed.
	Non-Rhythmic Sensory Stimuli	Buildings like the Süleyman Demirel Cultural Center have been given a raw concrete effect on their façades. These façades appeal to tactile and visual sensory perception.
	Thermal & Airflow Variability	Adequate window openings and climate control systems are positively evaluated for enhancing air circulation within the spaces.
	Presence of Water	Except for buildings, the campus has no artificial water features.
	Dynamic & Diffuse Light	Skylights are incorporated into the buildings, but no design has been observed to block unwanted infrared light.
	Connection with Natural Systems	There are elements such as plants, minimalist design, and calming workspaces within the campus buildings.
Natural Analogues	**Biomorphic Forms & Patterns**	The façade of the buildings features a shell system with biomorphic patterns.
	Material Connection with Nature	Using raw concrete material on the building facades in the Ayazağa Campus provides visual simplicity, appearing harmonious with nature.
	Complexity & Order	A regularity is observed among administrative, social, and academic units.
Nature of the space	**Prospect**	The buildings have yet to emphasise the idea of freedom, mobility, and flexibility.
	Refuge	Shelter measures for potential disasters have been implemented on campus.
	Mystery	The campus needs more mystery in-unit connections, but the pond and surroundings offer relaxing, naturally mysterious areas.
	Risk/Peril	No element posing a threat has been observed inside or outside the buildings.

The exposed concrete façades of Ayazağa Campus establish a natural connection through their visual simplicity. The central classroom building features a biomorphic-patterned façade, while the proximity of administrative, social, and academic units—requiring a 15-minute walk—promotes a structured campus environment. The raw concrete façades contribute to a visually harmonious integration with nature, and the biomorphic design of the central lecture building reinforces this connection.

DEU Tınaztepe Campus

The development of the Tınaztepe Campus follows this axis, reflecting a linear settlement model, with a social centre emerging at the point where a secondary route intersects this axis (Figure 6). The assessment of DEU according to biophilic design criteria, detailed in Table 7, shows potential for connecting with nature due to its natural greenery. Buildings use expansive windows to connect visually with the exterior, and outdoor areas are designated for relaxation and seating. However, the lack of coherence between enclosed, semi-open, and open spaces weakens this connection. The buildings are rectangular, courtyard-oriented, or comb-like, with 10-meter gaps impeding visual connectivity. The design does not incorporate sensory elements such as water features, pleasant sounds, or fragrances. Facades exhibit varied design approaches, lacking materials harmonious with nature, which diminishes sensory stimuli. Although window openings and climate control systems are adequate, artificial water features are missing, and thermal comfort considerations through light are overlooked.

Tınaztepe Campus lacks distinctive materials and biomorphic patterns for a nature connection. Its linear settlement model and layout enhance coherence, and courtyard buildings add mystery, with precautions for risk mitigation.

IU Avcılar Campus

The campus has a grid layout with four entrances; dormitories are in the southeast, the Faculty of Veterinary Medicine is in the northwest, and administrative and social spaces are centrally positioned (Figure 7).

The campus buildings are designed in rectangular, courtyard, C, U, and T shapes but lack essential environmental elements like plants and water features. Interior layouts do not strongly connect with nature, and sensory elements are missing.

Air circulation through windows and ventilation systems is positive, but the lack of integration with Küçükçekmece Lake, green areas, and water elements is a significant shortcoming. Windows admit natural light, but the desired thermal effect indoors is not achieved without sun-oriented design and facade systems.

Buildings on the IU campus lack biomorphic patterns and do not use site-specific or nature-related materials like stone, brick, or wood. The grid layout ensures readability and order. There is no direct visual connection to Lake Küçükçekmece, and courtyards do not evoke mystery. Despite being constructed from reinforced concrete, buildings will be renovated for disaster preparedness, and necessary interior precautions are in place.

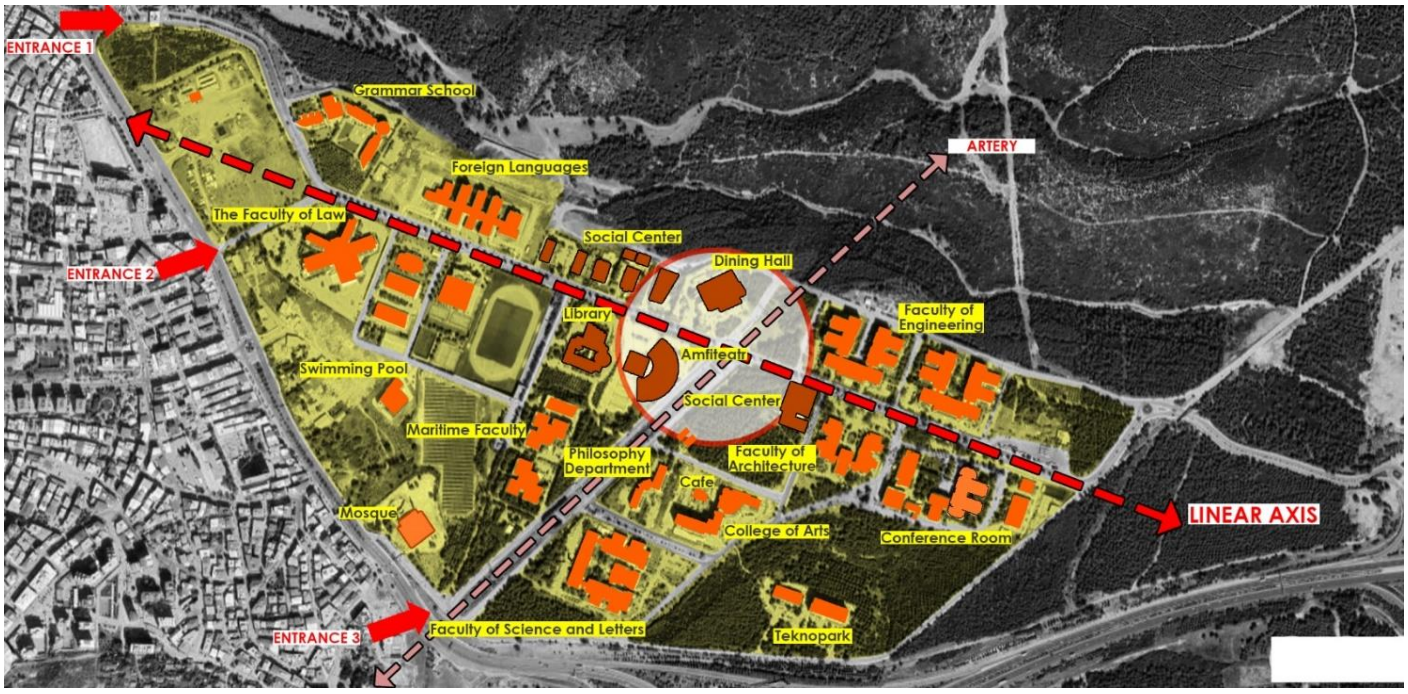


Figure 6. Physical Layout Analysis of DEU (Linear)

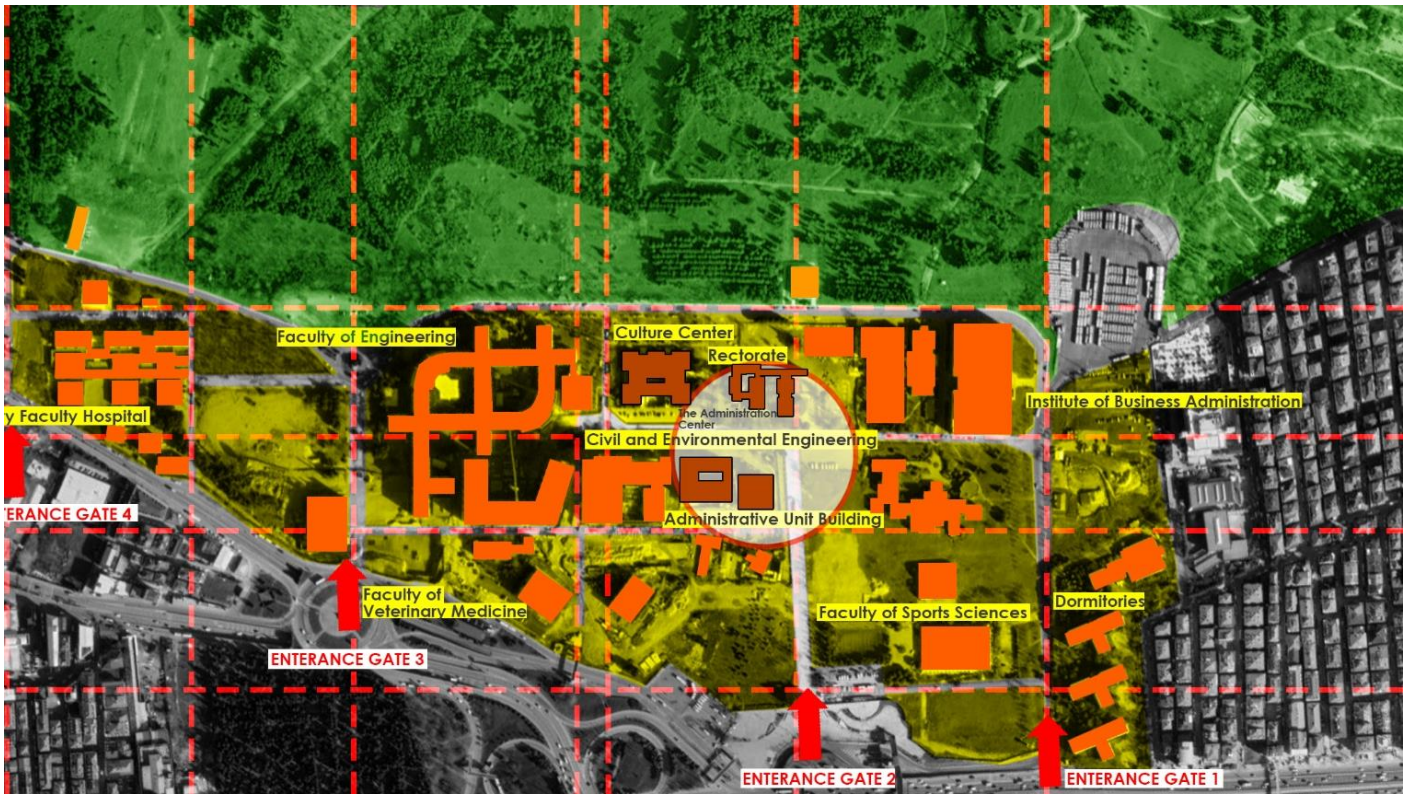
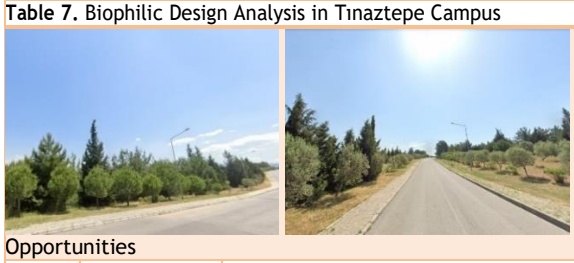


Figure 7. Physical Layout Analysis of IU (Gridiron)

Table 7. Biophilic Design Analysis in Tınaztepe Campus



Opportunities

	Patterns	Description
Nature in the space	Visual Connection with Nature	Large windows and outdoor seating areas create a visual connection with the exterior, but ineffective integration of enclosed, semi-open, and open spaces weakens this connection.
	Non-Visual Connection with Nature	The interior garden design of buildings with rectangular, courtyard, and comb-like forms must be improved to establish a better visual connection with the environment.
	Non-Rhythmic Sensory Stimuli	The campus buildings lack sensory elements like water features, pleasant sounds, or fragrances in their interior and exterior spaces, especially in resting and seating areas.
	Thermal & Airflow Variability	Adequate window openings and climate control systems are positive for air circulation within the spaces.
	Presence of Water	Within the campus, any natural or artificial water features are absent.
	Dynamic & Diffuse Light	Skylights are incorporated into the buildings, but no design has been observed to block unwanted infrared light.
	Connection with Natural Systems	The buildings within the campus lack elements such as plants and calming workspaces.
Natural Analogues	Biomorphic Forms & Patterns	No biomorphic forms have been observed.
	Material Connection with Nature	The buildings on the Tınaztepe Campus have not used any material specific to creating a connection with nature on their facades.
	Complexity & Order	The linear development of buildings on the Tınaztepe Campus creates a sense of order.
Nature of the space	Prospect	Despite shaping academic and social units, the campus topography does not create visual vistas.
	Refuge	Shelter needs have been primarily addressed through precautions against natural disasters.
	Mystery	The courtyard and comb-like buildings within the campus create a sense of mystery.
	Risk/Peril	No element posing a threat has been observed inside or outside the buildings.

Comparison of the Results of Biophilic Design Criteria for the Universities

This study examines biophilic design principles in university campuses by evaluating selected institutions in Turkey due to the challenges of assessing all universities. The campus organisation and development are classified according to Linde's (1971) settlement forms: diffuse, central, molecular, gridiron, cross, and linear. The case studies are ESOGU, TOGU, AU, ITU, DEU, and IU. The research aims to compare the levels of compliance with biophilic design standards in campus sites identified as case studies and to examine the effects of different campus layouts on biophilic design standards. This comparison is presented in Table 9.

As shown in Table 9, the architectural designs of the AU, ITU, and DEU campuses establish a visual connection with nature. However, only AU and ITU buildings integrate nature within atriums, galleries, and courtyards. TOGU and AU meet the criterion for non-rhythmic sensory stimuli. Thermal and airflow variability, dynamic and diffuse light, and related risk criteria are consistent across all universities. However, the universities have yet to incorporate the presence of water into their natural or artificial water design processes. Regarding connection with natural systems, TOGU and ITU campuses effectively use clinker bricks and concrete on their facades. Biomorphic forms and patterns are observed on some ITU building facades. Regarding material connection with nature, visual and tactile effects of site-specific materials are noted at TOGU and AU campuses. ITU, DEU, and IU campuses ensure regular interaction between social and administrative centres and academic units according to the Complexity and Order criterion. The Refuge criterion is negatively assessed for IU due to the need for shelters until old buildings are demolished. Atriums and comb-shaped arrangements at ESOGU, TOGU, and DEU address the Mystery criterion.

Table 8. Biophilic Design Analysis in Avcılar Campus

Opportunities

	Patterns	Description
Nature in the space	Visual Connection with Nature	The building design fails to bridge the interior-exterior gap or incorporate nature into semi-open spaces. Traditional shapes are used, but essential greenery and water features are neglected.
	Non-Visual Connection with Nature	Campus interiors should convey a sense of nature through rest areas, seating, and corridors.
	Non-Rhythmic Sensory Stimuli	Both open and enclosed spaces lack elements for all users' senses.
	Thermal & Airflow Variability	Ensuring air circulation through windows and proper ventilation systems is advantageous.
	Presence of Water	No water element has been integrated into the buildings.
	Dynamic & Diffuse Light	Buildings receive light through windows but lack proper orientation or façade systems to achieve the desired thermal effect indoors.
	Connection with Natural Systems	The campus buildings lack a spatial oasis with plants, soft surfaces, colourful wallpapers, and calming workspaces.
Natural Analogues	Biomorphic Forms & Patterns	No biomorphic forms have been observed.
	Material Connection with Nature	IU buildings lack materials that connect with nature on their facades.
	Complexity & Order	Administrative, social, and academic units show regularity.
Nature of the space	Prospect	The buildings lack emphasis on mobility and flexibility.
	Refuge	Renovation plans for specific campus buildings are underway for potential disaster scenarios.
	Mystery	Courtyards exist but do not evoke mystery.
	Risk/Peril	No threatening elements have been observed inside or outside the buildings.

Table 9. Comparison of the Universities

		ESOGU	TOGU	AU	ITU	DEU	IU
Nature in the space	Visual Connection with Nature	-	-	✓	✓	✓	-
	Non-Visual Connection with Nature	-	-	✓	✓	-	-
	Non-Rhythmic Sensory Stimuli	-	✓	✓	-	-	-
	Thermal & Airflow Variability	✓	✓	✓	✓	✓	✓
	Presence of Water	-	-	-	-	-	-
	Dynamic & Diffuse Light	✓	✓	✓	✓	✓	✓
	Connection with Natural Systems	-	✓	-	✓	-	-
Natural Analogues	Biomorphic Forms & Patterns	-	-	-	✓	-	-
	Material Connection with Nature	-	✓	✓	-	-	-
	Complexity & Order	-	-	-	✓	✓	✓
Nature of the space	Prospect	-	-	✓	-	-	-
	Refuge	✓	✓	✓	✓	✓	-
	Mystery	✓	✓	-	-	✓	-
	Risk/Peril	✓	✓	✓	✓	✓	✓

Recommendations for Developing Biophilic Campuses

Integrating biophilic principles into educational institutions' architectural design and campus planning can significantly impact students, faculty, and staff. This research shows that the case study universities must adhere to biophilic design standards. However, the potential for nature integration in these campuses is clear. Recommendations for maximising this potential include:

- University buildings' façade designs incorporating large windows and open or semi-open spaces can facilitate a visual connection with nature. This design approach reinforces the link between users and the natural environment (Figure 8).

Figure 8. Visual nature connection: a) Large windows, b) Semi-open Spaces, c) Open Spaces

- A non-visual connection with nature could be facilitated by Incorporating water and plant elements in areas such as galleries and corridors within the campus buildings, which can provide a richness that appeals to various senses, including visual, auditory, tactile, and olfactory (Figure 9).

Figure 9. Interaction with nature: a) Water feature, b) Rest areas, c) Floor lobby.

- To enhance the connection between campus structures and the natural environment, incorporating plant species suitable for specific climatic conditions and creating tranquil spatial arrangements can aid users in establishing a stronger bond with nature and effectively adapting to their surroundings (Figure 10).

Figure 10. Plants in seating and resting areas.

- Integrating natural elements like stone, wood, and locally sourced materials into campus building interior and exterior spaces is pivotal for fostering a strong connection with the surrounding environment. Embracing organic shapes and structures by deliberately utilising biomorphic forms enhances coherence and cultivates a profound sense of unity with the adjacent landscape (Figure 11).

Figure 11. Facade material details: a) brick-glass façade, b) wood-glass, and c) stone façade material.

- The construction of buildings on university campuses with designs that evoke curiosity increases the desire for exploration among individuals who will use the campus. This desire enhances the attractiveness of the campus and is anticipated to impact users (Figure 12) positively.

Figure 12. The spatial mystery: a) Site plan, b) Courtyard rendering, c) Interior view of the courtyard.

Implementing biophilic design patterns in university campuses positively impacts workspaces and the mental well-being of students, academics, and administrative staff. Therefore, it is recommended that university campuses prioritise the development of their designs by considering biophilic design patterns.

Discussion

The biophilic design approach enhances built environments by integrating natural elements and principles. However, the universities examined in this study—ESOGU, TOGU, AU, ITU, DEU, and IU—do not fully meet the biophilic design criteria to integrate nature and the built environment. Although these universities have significant potential to promote well-being and productivity, they fail to implement biophilic design principles. Making physical adjustments that align with biophilic design criteria in the selected university campuses can enhance the overall quality of life for students, faculty, and staff.

Future research should examine the long-term impacts of biophilic design in academic settings on student performance, well-being, and campus sustainability. Investigating tailored biophilic strategies for different disciplines and learning

environments could enhance effectiveness. Additionally, exploring the direct effects of biophilic design on learning processes and academic achievements would contribute valuable insights to the literature.

In conclusion, integrating biophilic design into university campuses can enhance the academic community's physical environment, well-being, and productivity while fostering more sustainable and livable settings. Thus, expanding biophilic design adoption is crucial for future research in sustainable architecture and urban planning.

Conclusion

The research uses biophilic design principles to assess how university campuses integrate with their natural surroundings. It focuses on ESOGU, TOGU, AU, ITU, DEU, and IU based on 14 principles by William Browning and colleagues. The study finds that these universities need to adopt biophilic design criteria fully. The following points should be considered to address discrepancies and align campuses with these principles.

The establishment of a visual connection with nature necessitates the use of expansive windows, the avoidance of deep spaces, and the incorporation of semi-open areas. These architectural elements facilitate user interaction with the environment.

- The incorporation of water and plant elements within the galleries and corridors of campus buildings can facilitate the creation of spatial arrangements that engage all the senses, thereby establishing a connection with nature.

- The architectural design of the campus buildings should aim to create a visually appealing vista by incorporating green spaces and natural or artificial water features. Furthermore, the interior and exterior spaces should be arranged by the building forms and should be planned in a manner that guides users towards these landscape elements.

- Using regionally sourced materials, such as stone, wood, and brick, within campus buildings' interior and exterior spaces reinforces biophilic design principles. Furthermore, using local materials engenders environments that evoke the essence of the locale, both aesthetically and culturally.

- Architectural designs reflecting the mystery of campus areas enhance campus life's dynamism and strengthen the academic environment's attractiveness.

Architectural designs on university campuses can enhance the connection between users and nature through biophilic design, which offers an alternative approach integrated with nature. The development of this connection can lead to increased productivity and quality of life, as well as enhanced physical and mental well-being among academic, administrative, and student populations. Furthermore, biophilic design can facilitate a more sustainable lifestyle by reinforcing the profound connection between humans and nature and enabling a more resilient relationship with the natural world. This study illuminates the transformative potential of biophilic design in academic environments, offering concrete recommendations in campus planning and architectural design. In conclusion, the broader adoption of biophilic design in future academic settings can enhance its potential to improve people's quality of life and coexist harmoniously with nature.

Peer-review: Externally peer-reviewed.

Ethics Committee Approval Certificate: The author declared that an ethics committee approval certificate is not required.

Conflict of Interest: The author has no conflicts of interest to declare.

Financial Disclosure: The author declared that this study has received no financial support.

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