

A Verification Tool for the Validity of Educational Environments According to the Biophilia Hypothesis

Nagham I. Yahya¹

¹Department of Architectural Engineering, Cihan University-Erbil, Kurdistan Region, Iraq

Abstract—Today's academic students spend a lot of time indoors, which puts them at risk for psycho-physiological stresses that have a negative impact on their cognition. This study aims to investigate the impact of incorporating biophilic design patterns in the academic environment on student motivation and to develop a verification tool that helps to design and evaluate educational buildings in terms of providing motivating learning environments in accordance with the biophilia hypothesis. The developed verification tool will be applied later to one of Eastern Mediterranean University's buildings in Northern Cyprus. To conduct the present study, a qualitative research method based on a case study analysis is adopted. Literature review for books, scholarly articles, and other sources relevant to the study issue is used, to understand the psychological impacts of incorporating the Biophilic Design patterns in an Educational environment on students' psychological health. Biophilic design indicators are extracted from a set of existing biophilic buildings in order to set the verification tool. The verification reveals that the case study featured nine biophilic design patterns, which have a positive impact on the learning process.

Keywords— Biophilia Hypothesis, Biophilic design patterns, motivating environment, psycho-physiological stresses.

I. INTRODUCTION

Most of the universities in Northern Cyprus specified five days a week, six-seven hours a day for lectures which means a large part of a student's daytime is spent inside the university. These students are liable to many psycho-physiological stresses that have adverse effects on cognitive performance. According to a study by Stanford University Wellbeing Task Force, there is growing mental health issues among the university's students in recent years (Terrapinbrightgreen.com). A study at the University of California found that continuous stress in the education environment may cause a harmful influence on the brain structure and function, which can affect the students' cognitive performance and make them liable to learning difficulties (Bergland, 2014).

Biophilic Design is an advanced concept in biophilia hypothesis, which depends on incorporating the elements of the

natural world within the built environment allowing humans to interact with nature while also improving human life (Yahya and Hassanpour,2022). It has been categorized into different patterns which have broad applications in interior design and architecture fields for purpose of achieving physiological, cognitive, and psychological benefits. In this context, the questions that arise are whether the use of biophilic design patterns in the academic environment can create a motivational environment for students and if it is possible to prepare a tool that can be used by students and scholars to design and evaluate academic environments in terms of comfort and motivation for students. The aim of this study is to investigate the impact of incorporating biophilic design patterns in the academic environment on student motivation and to develop a verification tool that helps to design and evaluate educational buildings in terms of providing motivating learning environments in accordance with the biophilia hypothesis. Throughout the study, the author verifies the validity of the lecture building (colored building) of the Faculty of Architecture at EMU University in Northern Cyprus, as a motivating environment.

II. METHODOLOGY

To conduct the present study qualitative research method based on the case study is adopted. Literature review for books, scholarly articles, and other sources relevant to the study is used to investigate the psychological impacts of incorporating biophilic design patterns in an academic environment on students' psychological health. Case study analysis is adopted to extract biophilic design indicators to develop a verification tool that will be used later to verify an educational building selected from one of the Middle Eastern universities.

III. LITERATURE REVIEW

A. *The Motivation in the Educational Environment*

Motivation is defined as internal and external factors that spur willingness and energy in people to keep interested and committed to a career, role, or subject, or to make an effort to achieve a goal (businessdictionary.com). Student motivation is an element that promotes the students' learning process. It is an important issue in higher education, due to the importance of

academic performance in the student's professional life (Fromm, 1964). Motivation includes a pleiad of beliefs, perceptions, values, interests, and actions that are all firmly related. As a result, achieving motivation can focus on cognitive behaviors such as monitoring and strategy use, and non-cognitive aspects such as perceptions, beliefs, attitudes, or both (Kellert, 2015). Motivation can be classified into two types: Inherent motivation and acquired motivation. Inherent motivation means that the students are motivated by themselves when they are motivated from within, while acquired motivation means that the students steadily involve themselves in learning out of oddity, interest, or enjoyment, to attain their own scholarly and personal self-goals (Fromm, 1964).

Maslow (1943) developed the famous theory of motivation, in the 1940s and 1950s. The theory summarizes human needs into five main categories that were arranged within a hierarchy, starting with the basic psychological needs and continuing through safety, belonging and love, esteem, and self-actualization (Figure 1).

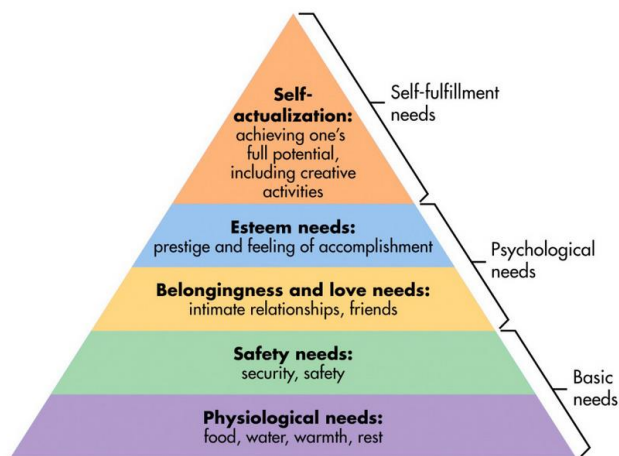


Fig. 1. Maslow's Hierarchy of Needs (McLeod, 2018)

According to this theory, the dominance of the need is related to satisfaction. In other words, the lowest unsatisfied need becomes the dominant need, and that requires taking action from the individual in order to fulfill this need and move to higher needs sequentially (McLeod, S., 2018). Accordingly, the fulfillment of the students' psychological needs inside the educational spaces motivates them to attain creative activities.

B. The Cognitive Performance

Valdez et al. (2008) defined cognition performance as an intellectual activity, describing the receiving, storage, modification, and use of information. It comprises various elements: attention (stimulating and progressive alertness, and selective and continuous attention), working memory (lingual, used for speech, reading, and writing; and visuospatial, drawing, and mathematics), and executive function (action, decision-making, and problem-solving). Recently, the reevaluation of the academic spaces' performance has raised interest in higher education institutions in order to enhance the learning process (Long & Ehrmann, 2005), accordingly, many studies about how to promote the students' cognition function

were achieved. Bergland (2014) stated that reducing Chronic Stress is one of the factors that influence students' cognition. Nilsson et al. (2011) suggested that the natural environments, which are experienced as stylishly satisfying and pleasant, consequently influence our sensory system, our feelings, and our cognition, and because of this help general human health processes.

C. The Biophilic Design Patterns

In the last decades, neuroscience and architecture have witnessed a growing body of research and practice development. The design field has begun to consolidate the biophilia green building models concerning indoor natural quality and human connection with the place (Terrapin Bright Green, 2014). The idea of biophilic design is that the built environment affects people's health, productivity, and emotional, intellectual, and spiritual well-being. The incorporation of elements of nature into the built environment has positive effects on human health psychologically and physiologically and in improving well-being and productivity (Lerner & Stopka, 2016).

The first time that the term 'biophilia' was used, in 1964 by the social psychologist Eric Fromm in his book "Essence of Man" (Fromm, 1964). Thereafter, sociobiologist Wilson (1984) examined and popularized the term in 1984 in his book Biophilia. In this book, the author defined biophilia as "the innate tendency to focus on life and lifelike processes" (Wilson, 1984). The presence of biophilia in architecture was in 2006 during a conference at Rhode Island in the US in 2006. In this conference, cross-disciplinary foundations for a biophilic design approach to the built environment were established. (Kellert, 2008).

Browning et al. (2014) referred to three methods to incorporate nature within the built environment: Nature in the Space, Natural Analogues, and Nature of the Space. Each method includes a set of patterns. The 14 Patterns relate human biology and nature to the design of the built environment. They help to understand the design opportunities and methods that lead to enhancing the health and well-being of building occupants.

The study illustrated the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement, and the human body.

According to the study:

1. Eight of the patterns can reduce human stress: (p1, p2, p3, p4, p5, p6, p10, p11).

2. Eight of the patterns can improve human performance: (p1, p2, p3, p4, p5, p9, p11, p12).

3. Eleven of the patterns have positive impacts on human emotion, mood & preference: (p1, p2, p4, p5, p7, p8, p9, p10, p11, p13, p14).

According to Browning et al. (2014), the 14 patterns have a wide range of applications for both interior and exterior environments and are intended to be flexible and adaptive, allowing for project-appropriate execution. So, these patterns are applied in different projects but with varying detail, location, and extent "Just as lighting design for a classroom will

be different than for a spa or home library, biophilic design interventions are based on the needs of a specific population in a particular space" (Browning et al., 2014).

IV. DERIVING BIOPHILIC DESIGN INDICATORS FROM EXISTING BIOPHILIC BUILDINGS

Terrapin Bright Green which is a consulting and strategic planning group and is considered to be an expert in the Biophilic Design field has many studies about the subject. A review of a set of studies that have been done by this group, for selected biophilic buildings which were constructed between 2006 and 2014, was achieved in order to understand how to employ the 14 patterns within the interior spaces. The selected Biophilic projects Bp (s) are shown in table I.

TABLE I
CASE STUDIES DESCRIPTION

No.	Biophilic Project	Country	Year
Bp1	Östra hospital psychiatric facility Göteborg	Sweden	2006
Bp2	Cookfox Architecture Studio New York, USA-2006	USA	2006
Bp3	Coeur D'alene Resort & Casino Idaho	USA	2011
Bp4	Parkroyal on Pickering Hotel	Singapore	2013
Bp5	Glumac Shanghai Office Shanghai	China	2014
Bp6	Kickstarter Commercial Headquarters	New York, USA	2014
Bp7	Windhover Contemplative Center & Art Gallery	Northern California, USA	2014

From the seven biophilic building examples, a set of strategies have been elicited (see Table II).

TABLE II
CASE STUDIES' BIOPHILIC DESIGN STRATEGIES (AUTHOR)

p1. Visual Connection with Nature

Description: This pattern is about employing strategies that ensure views of nature elements, systems, and processes (Terrapinbrightgreen.com).

Biophilic projects	Strategies
Bp1, Bp2, Bp3, Bp4, Bp5, Bp6, Bp7	- Excessive glass area ensures the visual connection with the adjacent landscape (garden, green roof, Garden courtyard, Sky-gardens, terrace)
Bp1, Bp2, Bp4, Bp6, Bp7	- Accessible green area (adjacent landscape, green roof, Garden courtyard, Sky-gardens, terrace)
Bp2, Bp4, Bp5	- Rich indoor plantings.
Bp5	- Skylight

p2. Non-Visual Connection with Nature

Description: This pattern is about employing strategies that stimulate the human non-visual senses (hearing, touch, smell, or taste) and incite a positive indication to nature elements, systems, or processes (Terrapinbrightgreen.com).

Biophilic projects	Strategies
Bp1, Bp2	- Operable windows allow sounds and smell from the adjacent landscape
Bp5	- Indoor plants bring a pleasant odor to the spaces
Bp1, Bp5, Bp7	- The Garden courtyard brings the sounds of the birds.
Bp6	- Edible garden plots (taste)
Bp7	- Natural floor texture (touch)

p3. Non-Rhythmic Sensory Stimuli

Description: This pattern is about employing strategies that ensure random fleeting connections with nature that can not be anticipated precisely (Terrapinbrightgreen.com).

Biophilic projects	Strategies
Bp1, Bp2, Bp6, Bp7	- Accessibility to native landscape to let the occupants feel breezes, see cloud movements, hear bird and insect sounds and see native landscaping.
Bp2	- skylight
Bp1	- Planted courtyards

p4. Thermal & Airflow Variability

Description: This pattern is about employing strategies that improve indoor air temperature and relative humidity, and provide cooling natural ventilation and surface temperatures that mimic natural environments (Terrapinbrightgreen.com).

Biophilic projects	Strategies
Bp1	- Large glass area that provides the occupants with warm sun spots due to the excessive natural lighting.
Bp1, Bp2, Bp5, Bp6	- Operable windows provide ventilation.
Bp5	- Doors open to the patio provide airflow.
Bp6	- Variability Glass garage door connecting sunroom and green roof porch, operable windows in the office
Bp7	- Exterior courtyards, sitting area close to the water surface

p5. Presence of Water

Description: This pattern is about employing strategies that ensure seeing, hearing, or touching the water, which can promote the human experience of a place. (Terrapinbrightgreen.com)

Biophilic projects	Strategies
Bp3	- Using the water surface along the entryway of the building.

Bp2	- Visible water retention process (The building captures water from the rooftop to create periodic flooding in the courtyard)
Bp5	- water pool

p6. Dynamic & Diffuse Light

Description: This pattern is about employing strategies that exploit the light and shadow that vary in intensities at different times of the day in order to create natural conditions inside the spaces.

Biophilic projects	Strategies
Bp3	- The building layout is organized to provide natural light depending on the most used spaces.
Bp2, Bp5, Bp6	- large glass area provides the interior with daylight
Bp1, Bp2, Bp5, Bp6	- Lightwell
Bp5	- Task-based lighting provides variability and control.
Bp5, Bp7	- Smart artificial lighting to ensure proper lighting level during the occupation/ ensures the gradual reduction of artificial lighting during daylight hours.
Bp5	- A dynamic glass to moderate the natural lighting level.
Bp7	- Building orientation leverages solar orientation
Bp7	- Vertical louvers create shadows on interior space surfaces, connecting the occupants to the sun's diurnal patterns.
Bp7	- Dark finishing materials emphasize light and shadow.

p7. Connection with Natural Systems

Description: This pattern is about employing strategies that raise awareness of natural processes, through the human realization of the seasonal and temporal changes of nature (Terrapinbrightgreen.com).

Biophilic projects	Strategies
Bp3	- The corridors overlook the native landscaping, and rainwater capture and retention in the courtyard.
Bp5	- Water, waste, and electricity systems are dependent on natural processes.
Bp5, Bp7	- The pedestrian walkways overlook the native landscaping and the planted courtyard to show the effects of weather and seasonal changes in nature.
Bp5, Bp7	- PV panels that are visible to the users to draw awareness of seasonal variations in solar radiation.
Bp1, Bp6	- The visual connection to the green area (garden courtyard, green roof, and terrace) shows the effects of weather and seasonal changes in nature.

Bp6	- The visual connection to an eatable vegetation garden keeps the occupants connected to the food source.
Bp7	- Rainwater capture and retention in the courtyard lets occupants witness site-specific natural processes and cycles.
Bp7	- Using the deciduous trees along the entry path.

p8. Biomorphic Forms & Patterns

Description: This pattern is about employing strategies that depend on using natural materials, natural texture, or numerical arrangements that endure in nature. (Terrapinbrightgreen.com)

Biophilic projects	Strategies
Bp3, Bp4	- Biomorphic furniture and light fixtures
Bp2	- Botanical detailed column caps and coffered ceiling
Bp2	- Biomorphic carpet patterns
Bp5	- Biomorphic installation
Bp4	- Woodwork furniture
Bp6	- Fractal pattern finishes
Bp7	- Biomorphic shading devices

p9. Material Connection with Nature

Description: This pattern is about employing strategies that provide minimally processed natural materials and elements, reflect the ambient ecology or geology and create a distinct sense of place (Terrapinbrightgreen.com).

Biophilic projects	Strategies
Bp1, Bp2, Bp3, Bp5, Bp7	- The use of minimally processed materials as interior design elements.
Bp5	- Reclaimed furniture (wood reception desk and bistro table).
Bp5	- Reclaimed finishing materials (gray bricks).
Bp6	- Reclaimed furniture (Desks and seating)

p10. Complexity & Order

Description: This pattern is about employing strategies that provide copious sensory data which cohere with the spatial hierarchy like those experienced in nature. (Terrapinbrightgreen.com)

Biophilic projects	Strategies
Bp2	- Using the complexity in the pattern of the tiles
Bp1	- Using complexity and order in spatial configuration (repeated L-shaped pattern)
Bp4, Bp6	- Using complexity and order in interior design elements (Lattice pattern in the spiral staircase, fractal geometries, library bookshelves design)

p11. Prospect

Description: This pattern is about employing strategies that provide an unimpeded view over a distance, for monitoring and planning (Terrapinbrightgreen.com).

Biophilic projects	Strategies
Bp1, Bp2, Bp3, Bp5,	- Large windows provide unlimited external natural views.
Bp6, Bp7	- Variety of unimpeded natural views on a different level.
p12. Refuge	
Description: This pattern is about employing strategies that provide isolated places from the surrounding environment or the fundamental flow of action. (Terrapinbrightgreen.com)	
Biophilic projects	Strategies
Bp1, Bp2, Bp3, Bp6	- Private sitting areas (high-backed seats, Reading corners, cubbies, movable partitions).
Bp5, Bp7	- To isolate the indoor building environment from the city (using the central planted courtyard, the location of the building in the forested area).
p13. Mystery	
Description: This pattern is about employing strategies that motivate individuals to travel deeper into the built environment to discover the interior spaces. (Terrapinbrightgreen.com).	
Biophilic projects	Strategies
Bp3, Bp5	- The sudden transition between spaces with different properties (transition from narrow, dark corridor to the daylight wide hall, the walkways ended with a partially darkened natural view).
Bp7	- The entry setback.
p14. Risk/Peril	
Description: This pattern is about employing strategies that provide recognizable risk combined with a dependable defense (Terrapinbrightgreen.com).	
Biophilic projects	Strategies
Bp4, Bp6	- The visual connection to the ground from great heights.

V. DEVELOPING THE VERIFICATION TOOL

The 14 biophilic design patterns and strategies extracted from the case studies were developed into an indicator-based verification tool (see Table III).

TABLE III
BIOPHILIC DESIGN ASSESSMENT TOOL (AUTHOR)

Ps	Indicators	√ / ×
----	------------	-------

p1	- Excessive glass area ensures the visual connection to the adjacent landscape	
	- Accessible green area (adjacent landscape, green roof, Garden courtyard, Sky-gardens, terrace)	
	- Employing rich indoor plantings.	
	- Skylight	
p2	- Operable windows allow sounds and smell from the adjacent landscape	
	- Indoor plants bring pleasant odor to the spaces	
	- Garden courtyard brings sounds of the birds.	
	- Edible garden plots (gustatory)	
p3	- Natural floor texture	
	- Accessible native landscape (let the occupants feel breezes, see cloud movements, hear bird and insect sounds and see native landscaping),	
	- skylight	
p4	- Planted courtyards let the occupants feel breezes, see cloud movements, and hear bird and insect sounds	
	- Using large glass areas that provides the occupants with warm sun spots due to the excessive natural lighting.	
	- Operable windows provide ventilation.	
	- Doors open to the patio.	
p5	- Variability Glass garage door connecting sunroom and green roof porch, operable windows in the office	
	- Exterior courtyards, seating near the reflection pool	
	- Using the water surface along the entryway of the building.	
p6	- Visible water retention process (The building captures water from the rooftop to create periodic flooding in the courtyard)	
	- water pool	
	- The building layout was organized to provide natural light depending on the most used spaces.	
	- large glass area provides the interior with daylight	
	- A light well	
	- Task-based lighting provides variability and control	
	- Smart artificial lighting to ensure proper lighting level during the occupation/ ensures the gradual reduction of artificial lighting during daylight hours.	
- A dynamic glass to moderate the natural lighting level.		
p7	- Building orientation leverage solar orientation	
	- Incorporate vertical louvers casting shadows along the floor, connecting the occupants to the sun's diurnal patterns.	
	- Dark finishes materials emphasize light and shadow.	
p7	- The corridors overlook the native landscaping, and rainwater capture and retention in the courtyard.	

	<ul style="list-style-type: none"> - Water, waste, and electricity systems are dependent on natural processes. 	
	<ul style="list-style-type: none"> - The pedestrian walkways overlook the native landscaping and the planted courtyard to show the effects of weather and seasonal changes in nature. 	
	<ul style="list-style-type: none"> - PV panels that are visible to the users to draw awareness of seasonal variations in solar radiation. 	
	<ul style="list-style-type: none"> - The visual connection to the green area (garden courtyard, green roof, and terrace) shows the effects of weather and seasonal changes in nature. 	
	<ul style="list-style-type: none"> - The visual connection to an eatable vegetation garden keeps the occupants connected to the food source. 	
	<ul style="list-style-type: none"> - Rainwater capture and retention in the courtyard lets occupants witness site-specific natural processes and cycles. 	
	<ul style="list-style-type: none"> - Deciduous trees along the entry path. 	
p8	<ul style="list-style-type: none"> - Biomorphic furniture and light fixtures - Botanical detailed column caps and coffered ceiling. - Biomorphic carpet patterns. - Biomorphic installation. - Woodwork furniture. - Fractal patterns finish. - Biomorphic shading devices. 	
p9	<ul style="list-style-type: none"> - The use of minimally processed interior design elements. - Reclaimed furniture. - Reclaimed finishing materials. 	
p10	<ul style="list-style-type: none"> - Using the complexity in the pattern of the tiles - Using complexity and order in spatial configuration (e.g. repeated L-shaped pattern) - Using complexity and order in interior design elements (e.g. Lattice pattern in the spiral staircase, library bookshelves design) 	
p11	<ul style="list-style-type: none"> - Large windows provide unlimited external natural views - Variety of unimpeded natural views on different levels. 	
p12	<ul style="list-style-type: none"> - Private sitting areas (high-backed seats, reading corners, cubbies, and movable partitions provide private sitting for the occupants). - Isolation of the internal environment of the building of the city (Central planted courtyard, the location of the building in the forested area). 	
p13	<ul style="list-style-type: none"> - The sudden transition between spaces with different properties (transition from narrow, dark corridor to the daylit wide hall, the walkways ended with a partially darkened natural view). - Setback entry 	
p14	<ul style="list-style-type: none"> - The visual connection to the landscape from great heights. 	

VI. VERIFICATION OF THE CASE STUDY

One of Eastern Mediterranean University's architecture faculty buildings is the colored building (see Figure 2). This building has a restaurant, lecture rooms, seminar halls, design studios, and other amenities. To achieve the verification, the author used the verification tool to verify whether the building has exploited nature's advantages to improve the learning process (see Table IV).

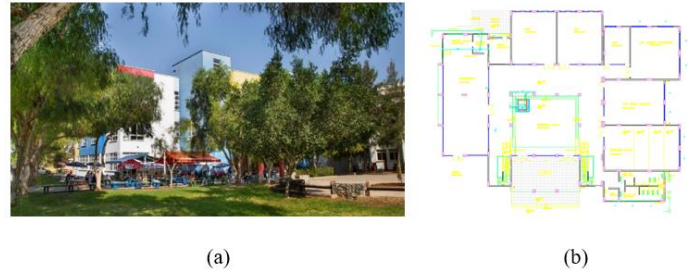


Fig. 2. The lecture building (Colored building) of Architecture Faculty in EMU University (a) Colored Building (b) Ground Floor (Reference: EMU University)





Fig. 3. Colored building (Author)

TABLE IV
COLORED BUILDING PERFORMANCE ACCORDING TO BIOPHILIC DESIGN PATTERNS (AUTHOR)

Ps	Indicators	Biological Responses
p1 Visual connection with nature	<ul style="list-style-type: none"> - Excessive glass area ensures the visual connection to the adjacent landscape (Figure 3-a). - Accessible green area (adjacent landscape, green roof, Garden courtyard, Sky-gardens, terrace) (Figure 3-f). - Skylight (Figure 3-b). 	<ul style="list-style-type: none"> - Reduce the stress - Improving Cognitive Performance - Enhancing the Emotion, mood & preference
p2 Non-Visual Connection with Nature	Operable windows allow sounds and smell from the surrounding landscape (Figure 3-c).	<ul style="list-style-type: none"> - Reduce the stress - Improving Cognitive Performance - Enhancing the Emotion, mood & preference

p3 Non-rhythmic sensory stimuli	<ul style="list-style-type: none"> - Accessible native landscape (let the occupants feel breezes, see cloud movements, hear bird and insect sounds, and see native landscaping) (Figure 3-f). - Skylight (Figure 3-b). 	<ul style="list-style-type: none"> - Reduce the stress - Improving Cognitive Performance
p4 Access Thermal & Airflow variability	<ul style="list-style-type: none"> - large glass area provides the occupants with warm sunspots due to the excessive natural lighting (Figure 3-a). - Operable windows provide ventilation (Figure 3-c). - Doors open to a patio (Figure 3-e). 	<ul style="list-style-type: none"> - Reduce the stress - Improving Cognitive Performance - Enhancing the Emotion, mood & preference
p6 Dynamic & diffuse light	<ul style="list-style-type: none"> - A large glass area provides the interior with daylight (Figure 3-a, 3-b). - Building orientation leverages solar orientation (Figure 3-a). 	<ul style="list-style-type: none"> - Reduce the stress - Improving Cognitive Performance - Enhancing the Emotion, mood & preference
p7 The connection with natural systems	<ul style="list-style-type: none"> - The visual connection to the green area shows the effects of weather and seasonal changes in nature (Figure 3-c, 3-d) 	<ul style="list-style-type: none"> - Enhancing the Emotion, mood & preference
p10 Complexity & order	<ul style="list-style-type: none"> - Using complexity and order in interior design elements. (Figure 3-g). 	<ul style="list-style-type: none"> - Reduce the stress - Emotion, mood & preference Improvement
p11.Prospect	<ul style="list-style-type: none"> - Large windows provide unlimited external natural views (Figure 3-c). 	<ul style="list-style-type: none"> - Reduce the stress - Improving Cognitive Performance - Enhancing the Emotion, mood & preference
p12.Refuge	<ul style="list-style-type: none"> - Isolating the indoor building environment from the city by the location of the building in the forested area (Figure 3-c). 	<ul style="list-style-type: none"> - Improving Cognitive Performance

VII. DISCUSSION AND FINDINGS

Students' psychological well-being, motivation, and creativity have all been demonstrated to increase when biophilic design patterns are used in learning environments. The colored building at Eastern Mediterranean University's faculty of architecture provides its students with a motivating learning environment, according to a survey based on biophilic design indicators. The indoor environment of the building and the surrounding landscape are closely integrated, and nine biophilic design patterns have been identified that have positive effects on students' mental health and cognitive.

CONCLUSION

The idea that there is an inherent link between people and nature underlies the biophilic design concept. Architecture that incorporates natural elements satisfies an essential human desire, which has numerous psychological and physical benefits. The psycho-physiological stresses that students experience in the learning environment have a negative impact on their ability to think clearly. The improvement of psychological health that results from incorporating biophilic design principles into educational facilities inspires students and helps the learning process. By using the proper Biophilic Design patterns, educational environments can be promoted to contribute to the learning process more effectively. When designing new academic buildings or making improvements to the ones that already exist, designers might rely on the developed verification tool that incorporates biophilic design indications.

REFERENCES

- Bergland, C. (2014). Eight Habits that Improve Cognitive Function. Psychological today. Retrieved from <https://www.psychologytoday.com/intl/blog/the-athletes-way/201403/eight-habits-improve-cognitive-function>.
- Browning, W., Ryan, C., & Clancy, J. (2014). 14 Patterns of biophilic design: Improving health and well-being in the built environment. New York: Terrapin Bright Green LLC. Fromm, E. (1964). *The Heart of Man*. Harper & Row.
- <http://www.businessdictionary.com/definition/motivation.html>.
- <http://www.terrapinbrightgreen.com>
- Kellert, S. (2015). What Is and Is Not Biophilic Design? [Blog]. Retrieved from <https://www.metropolismag.com/architecture/what-is-and-is-not-biophilic-design/>
- Kellert, S.R.; Heerwagen J. & Mador, M. (2008). *Biophilic design: the theory, science, and practice of bringing buildings to life*. Hoboken, N.J.: Wiley.
- Lerner, A. & Stopka, M. (2016). *The Financial Benefits of Biophilic Design in the Workplace: A Review and Summary of Current Research*. Mist Environment, Limited.
- Long, P. & Ehrmann, S. (2005). *Future of the Learning Space: Breaking Out of the Box* [Blog]. Retrieved from <https://er.educause.edu/articles/2005/1/future-of-the-learning-space-breaking-out-of-the-box>.
- Maslow, A. (1943). A theory of human motivation. *Psychological Review*, 50(4), 370-396. doi: 10.1037/h0054346.
- McLeod, S. (2018). Maslow's Hierarchy of Needs [Blog]. Retrieved from <https://www.simplypsychology.org/maslow.html>.
- Newman, P. & Soderlund, J. (2015). Biophilic architecture: a review of the rationale and outcomes. *AIMS Environmental Science*, 2(4), 950-969. doi: 10.3934/environsci.2015.4.950.
- Nilsson, K.; Sangster, M.; Gallis, C.; Hartig, T.; Vries, S.; Seeland, K. & Schipperijn, J. (2011). *Forests, trees and human health*. London: Springer.
- Terrapin Bright Green. (2014). *14 Patterns of Biophilic Design-Improving Health & Well-Being in the Built Environment*.
- Ulrich, R. (1984). View through a window may influence recovery from surgery. *Science*, 224(4647), 420-421. doi: 10.1126/science.6143402.
- Valdez, G.R.; Thomas, K.E.; Goodrich, E.; Dekker, K.M. (2008). Kappa Opioid Receptor Antagonism of the Behavioral Stress Response Following Chronic Exposure to Ethanol. Annual Meeting of the Society for Neuroscience. Washington, DC.
- Wilson, E. (1984). *Biophilia*. Cambridge, MA: Harvard University Press.
- Yahya, N. & Hassanpour, B. A. (2022). Methodical Framework for Sustainable Architectural Design: Housing Practice in the Middle East. *Land*, 11, 1019. <https://doi.org/10.3390/land11071019>