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Incorporating Biophilic Design Strategies to Improve Employees' Psychological Restoration in the Work Environment

Mariam Abd Elkader[1], Naglaa A. Megahed [2], Sara Eltarabily[3]*

[1] *Architecture and Urban Planning Department, Faculty of Engineering, Port Said University, Port Said, Egypt, email:* mariam_abd_elghany@eng.psu.edu.eg

[2] Architecture and Urban Planning Department, Faculty of Engineering, Port Said University, Port Said, Egypt, email: Naglaaali257@eng.psu.edu.eg,

[3] *Architecture and Urban Planning Department, Faculty of Engineering, Port Said University, Port Said, Egypt, email:* sara_eltarabily@eng.psu.edu.eg,

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ABSTRACT

Over the past few decades, with the psychological restoration benefits of integrating nature into buildings, particularly in workspaces where stress levels are rising, the restorative benefits of being in touch with nature have emerged as a multidisciplinary field. Work stresses and restrictions lead to physical and psychological strains, amplified by poorly designed work environments, which in turn affect productivity and innovation. Consequently, a question arises regarding how to incorporate biophilic design attributes into the work environment to support psychological restoration. Therefore, this study proposed a biophilic design framework with specific design attributes to support restoration Subsequently, the study evaluates the framework by analysing three global case studies and examining strategies related to biophilic design, functional well-being, and social well-being, all aimed at supporting employees' restoration. Results indicate the effectiveness of integrating natural light, natural landscapes, and other proposed biophilic attributes to improve employees' restoration. In addition, the proposed well-being characteristics, like flexible, collaborative, and social gathering spaces, can support and speed up the restoration.

In particular, the proposed guiding model can be considered more effective in incorporating and evaluating strategies supporting restoration in the work environment. Additionally, the guiding model helps to integrate biophilic attributes to promote restoration, which establishes the foundation for further research to expand the examination of the additional advantages of biophilic design.

Keywords: Biophilic Design, Psychological Restoration, Workspace, Social Well-Being, Functional Well-Being.

1. INTRODUCTION

Since we spend 90% of our time in contemporary cities and buildings that are separated off from nature, the built environment has supplanted people's natural habitat [1, 2]. Consequently, the effects on human mental health and psychological well-being are catastrophic [3, 4]. Therefore, the term "biophilic design," which is thought to be at the core of our understanding of how to incorporate nature into our built environments to support psychological health, has emerged in recent years, giving the debate about nature incorporation new prominence [5]. People instinctively need daily contact with nature, especially in workspaces where most people spend half of their day and years of their lives in these spaces. Employees are exposed to a lot of stress that causes their energy and ability to focus to be exhausted, and therefore they are in dire need of psychological restoration to continue working productively and creatively [6]. Adults work in offices for more than 80% of the day and spend nearly one-third of it at work [7, 8]. The level of stress at

work is increasing. According to the National Institute for Occupational Safety and Health, 25% of adults said that their jobs were the biggest source of stress in their lives, and 26% said that they were extremely burned out at work [9]. As humans spend increasingly more time in the work environments, Employees' psychological health issues and their need for restoration are becoming more prevalent [10].

Stress reduces productivity, and prolonged stress can lead to long-term health problems [11]. Recent studies increasingly highlight that biophilic design attributes can effectively support psychological restoration in the work environment [8, 12, 13]. As biophilic attributes, daylight and plants have been evaluated in pilot experiments to demonstrate their ability to improve productivity and well-being in workspaces [14-16]. Biophilic design attributes can enhance cognitive performance in workspaces [8]. Moreover, biophilic design attributes in workspaces can positively affect employees' well-being [17]. On the other hand, many studies illustrate the characteristics of the workspaces to increase their employees' well-being [18-20].

What aspects have not been sufficiently covered?

Previous studies have focused more on the impact of biophilic design on the environmental, health, and productivity aspects. At the same time, previous studies have not dealt with determining the biophilic design strategies that support psychological restoration to help designers integrate and evaluate it. Further, the question remains regarding the biophilic design attributes that influence psychological restoration. And the design strategies to integrate these attributes into the work environment to incorporate and evaluate the employees' psychological restoration. Accordingly, this study aims to cover this gap by providing a guiding model with strategies to support employees' psychological restoration and evaluate the restoration value in the work environment. Consequently, this study is organized as follows: Section 2 focuses on submitting the proposed biophilic design framework by analysing and merging the biophilic design attributes. Then workspace case studies are described and analysed based on the proposed biophilic design framework in Section 3. Moreover, the results and discussion are presented in Section 4. Section 5 illustrates the proposed guiding model. Finally, the conclusions are discussed in Section 6 (as shown in Figure 1).

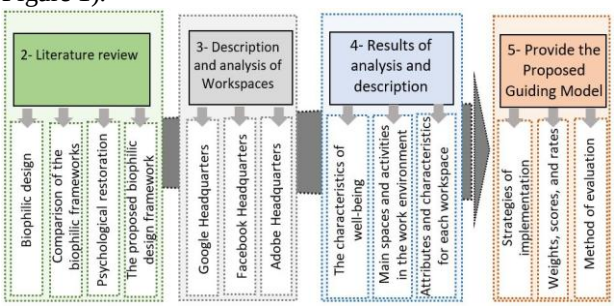


Figure 1: The study workflow diagram. Source: the authors.

2. LITERATURE REVIEW

2.1 Biophilic Design

Biophilic design was defined by Kellert as "the attempt to translate the inherent human affinity to affiliate with natural systems and processes into the design of the built environment" [21, 22]. In this study, biophilic design is defined as the process of incorporating nature into the built environment through specific attributes (e.g., natural light, air, visual connection with nature, etc.) that assist designers in choosing the best course of action to attain the greatest results for mental and psychological health. To facilitate the transition from biophilic theory to application in the built environment, this study asserted that biophilic design helps to improve psychological restoration by offering some design guidelines. In recent years, researchers have investigated a variety of biophilic design frameworks that usually differed in how they were structured. Still, two major groupings seemed to be the most comprehensive and relevant to architectural applications to psychological restoration support, which are Kellert framework [23] and Rayan and Browning framework [24]. Because these are the most frequently cited frameworks in the literature related to psychological aspects and are often referenced in building certificates' assessment criteria [8, 25, 26]. In addition, they address design strategies for integrating biophilic design attributes into the built environment. [8].

Therefore, the next section will compare these two frameworks to arrive at the proposed attributes of biophilic design.

2.2 Comparison of Biophilic Design Frameworks

Kellert presented a framework with two dimensions, six elements, and over seventy attributes [27]. Similarly, the Terrapin Bright Green firm introduced fourteen biophilic design patterns in 2014 to create a framework for enhancing health and well-being in the built environment [28]. Kellert then presented a new framework with 24 attributes in 2015, simplifying his original one. In 2018, he added a new attribute to the framework [23]. Likewise, Browning and Ryan created the framework in 2020 and included an additional attribute [24]. Since they are the most recent and often referenced frameworks in the literature on psychological restoration, these are the most significant motivating frameworks for biophilic design [25]. For this reason, as indicated in Table 2, this study chose these two frameworks to perform the comparative analysis in order to arrive at the suggested attributes. Similar attributes like light, air, water, prospect, and complexity have been added to the proposed framework. Some attributes merged into one attribute, like "plants" and "animals" can merge into "visual connection with nature," and "natural materials" and "natural colours" merge into "natural materials and colours" in the proposed framework. Some attributes are

excluded from the proposed attributes, like "fire" in the Kellert framework due to the fire risk, especially in high-rise buildings. In a similar vein, the uncertainty of producing erratic psychological reactions and distractions is frequently associated with "non-rhythmic sensory," "risk," and "awe" in the Rayan and Browning framework. These attributes therefore don't fit the requirements for biophilic design [25, 29]. According to recent research, natural attributes have the biggest impact on restoration. In this context, 'air' increases comfort, well-being, concentration, and spatial pleasure [28, 30-34]. Additionally, other research [35-40] showed that the presence of "water" can boost psychological responsiveness, positive emotional reactions, concentration, and stress reduction. Other studies noted that natural landscapes and ecosystems lower stress levels and enhance brain activity, cognitive function, and satisfaction [41, 42]. And 'natural light can also increase visual comfort and well-being [28, 43, 44]. Moreover, 'non-visual connection with nature' positively affects people's health, mood, and task performance [4, 29, 45]. However, indirect natural qualities such as "natural materials and colours" have been the subject of some research [24, 46]. Conversely, only a few investigations have examined the characteristics of space, how they affect restoration, and how to use them in design. In this context, 'prospect and refuge' reduces stress and improves comfort and perceptual attention [37, 47, 48]. Also, 'organized complexity' can support human well-being and reduce stress [2, 47, 49-51]. Moreover, other studies noted that 'integrated structural form' is important to preference and perceptual pleasure [37, 47, 52], and 'mystery' can increase pleasure responses [47]. Consequently, this paper proposes 15 biophilic attributes, as shown in Table 1, to reduce overlaps in existing biophilic frameworks.

Therefore, the next section of this paper identified the attributes that were most useful from the standpoint of psychological restoration, in preparation for presenting design strategies in the guiding model later.

2.3 Psychological restoration

The concept of psychological restoration is predicated on the idea that most people's cognitive and emotional systems are under pressure to adapt to the complex world they currently live in. Like all biological systems, these systems are thought to have limited resources that can be depleted [53]. Theories like Attention Restoration Theory ART [54] and Stress Reducing Theory SRT [55] contend that it is possible to replenish these depleted resources by exposing people to natural environments that place comparatively low demands on their cognitive and emotional systems and have the advantage of reducing stress-related negative emotions and enhancing positive ones (thus the term "psychological restoration"). Through the lens of biophilic design, examining the attributes that promote psychological restoration stimulates more research into psychologically oriented theories, including SRT and ART [53, 56]. ART focuses on cognitive aspects and highlights the ability to restore direct attention through being away, fascination, extent, and compatibility attributes can support psychological restoration [57-60]. On the other hand, SRT focuses on physical and emotional aspects; in other words, stress can be lessened in a natural environment to alleviate negative thoughts and replace them with positive emotions [31, 61-66]. Ulrich defined six attributes of SRT; presence of nature, complexity, gross structural properties, depth cues, ground surface encouraging movement, mystery, and absence of threats [25, 67-70].

Table 1. Comparison between Kellert 2018 and Ryan and Browning 2020 frameworks. Source: the authors, based on: [23, 24].

25 attributes of biophilic design, Kellert 2018		
Direct experience of nature	Indirect experience of nature	Experience of space and place
Light	Images of nature	Prospect and refuge
Air	Natural materials	Organized complexity
Water	Natural colours	Integration of parts to wholes
Plants	Simulating natural light and air	Transitional spaces
Animals	Naturalistic shapes and forms	Mobility and way finding
Weather	Evoking nature	Cultural and ecological attachment to place
Natural landscapes and ecosystem	Information richness	
Views	Age, change, and the patina of time	
Fire	Natural geometries	
	Biomimicry	
15 attributes Ryan & Browning, 2020		
Nature in the space	Natural analogues	Nature of the space
Visual connection with nature	Biomorphic forms & Patterns	Prospect
Non-visual connection with nature	Material connection with nature	Refuge
Nature Non-rhythmic	Complexity & order	Mystery
sensory stimuli		Risk & peril
Thermal & airflow variability		awe
Presence of water		
Dynamic & diffuse light		
Connection with natural systems		

Certain attributes of SRT and ART overlapped and were related, such as the "absence of threat" in SRT and the "being away" in ART. Furthermore, "depth and mystery" and "scope," as defined by ART, are similar; more "gross structural properties and presence of nature" can result in "soft fascination" to refocus the directed attention [60, 66, 71]. The attributes of SRT and ART are shown to overlap with those in the suggested framework of biophilic design. There are similarities between fascination and a variety of direct and indirect natural characteristics, such as a visual connection to nature, images of nature. In a similar vein, in biophilic design, being away could also represent prospect and refuge.

However, the attributes of biophilic design are absent "coherence", "compatibility", and "scope". According to this paper, combining biophilic design attributes with SRT and ART will result in design attributes emphasizing users' psychological restoration [72]. Thus, by studying and investigating their attributes to support the psychological restoration, this study suggests adding the following attributes to the proposed biophilic framework: 'access', 'openness', 'compatibility', 'coherence', 'depth', that have proven their impact on psychological restoration according to recent studies [2, 59, 61-64, 71-74].

2.4 The Proposed Biophilic Design Framework

Therefore, after analysing the proposed biophilic design attributes and studying the overlaps and intersections between them and the attributes of SRT and ART, The study reached 20 attributes that most support restoration. The proposed framework (as shown in Figure 2) includes 20 attributes classified into two broad categories:

2.4.1 Attributes That Permitting Restoration

Including the attributes that must be present in the built environment to allow the restoration process to occur. By achieving them, the user avoids the demands that led to the need for restoration and avoids encountering new demands that would further strain the already depleted resources [75], which are: B01, B02, B03, and B04.

2.4.2 Attributes That Promoting Restoration

Insofar as a built environment has attributes that promote restoration that draw a user's thoughts away from demands, attracting their attention, the person can better interact with the environment more effectively and extend the restorative process [75]. Including 16 attributes divided into 3 categories; natural attributes, indirect natural attributes, and space and place attributes.

In the work environment, functional and social well-being, besides biophilic design, contribute to psychological restoration, helping employees recharge and maintain productivity. Therefore, the next section will describe and analyse three case studies of workspaces based on the proposed biophilic design framework and investigate functional and social well-being strategies in the case studies that support psychological restoration.

3. DESCRIPTION AND ANALYSIS OF WORKSPACE SAMPLES

The following section describes and analyses selected international workspaces, based on the proposed framework. However, the selected case studies represent the phenomenon of interest by exploring the similarities and differences of each case. A multiple case study allows the researcher to examine differences within and between cases, according to Yin [77]. Replicating results across cases is the aim. To predict similar results across cases or contrasting results based on a theory, the researcher must carefully select the cases because comparisons will be made [78].

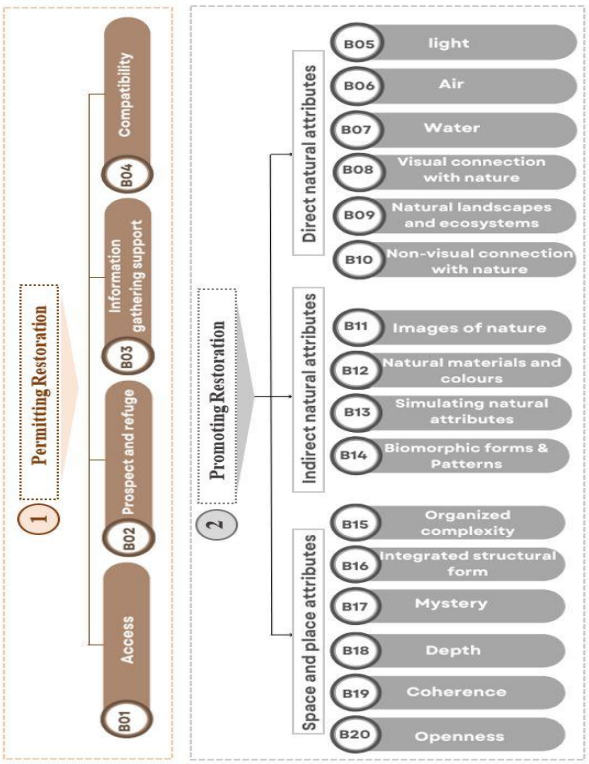


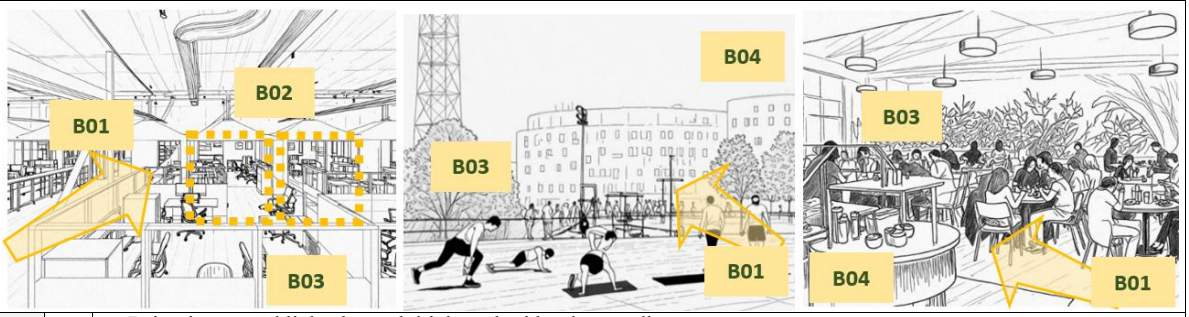
Figure 2: The proposed framework of biophilic design. Source: the authors.

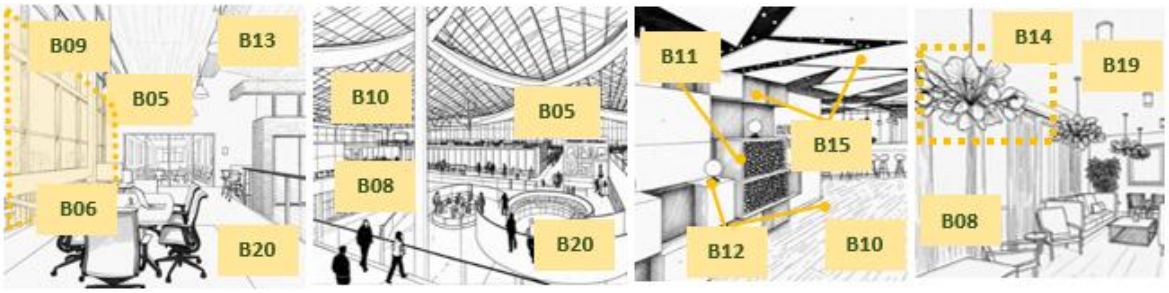
Criteria for selecting case studies:

- The case studies have achieved high psychological restoration and well-being rates for their employees [79-81]. The case studies have been recognized by Glassdoor's 2023 and 2024 list of the top 100 best places to work because they provide their employees with high-quality work environments [79][96,97]. The work environment must have at least 75 Glassdoor ratings to be listed among the 100 Best Places to Work by conducting employee satisfaction surveys [82].
- The selected cases are headquarters since they have -employees who vary in age, culture, and nationality and various industrial types (i.e., computer, financial services, internet services, etc.).
- The case studies must contain one or more of the biophilic design attributes identified in the proposed framework.
- The date of establishment between 2005 and 2024.
- Winner of one of the international architectural awards that is concerned with integrating nature into the built environment.

3.1 Google Headquarters

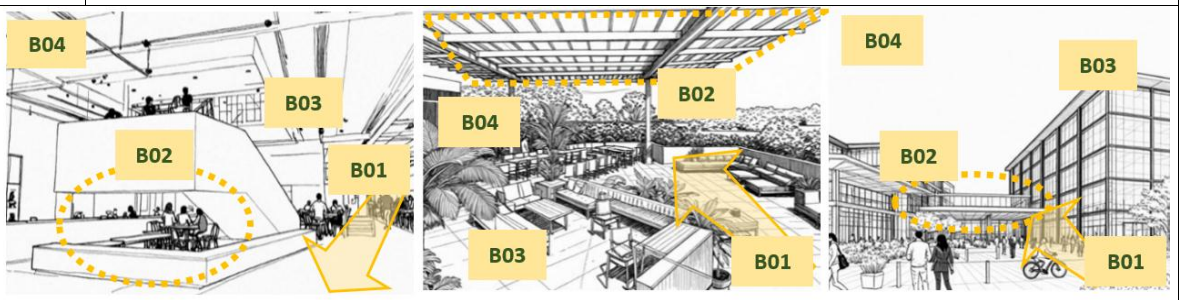
Table 2. Sample 1 definition. Source: the authors, based on: [79, 80].

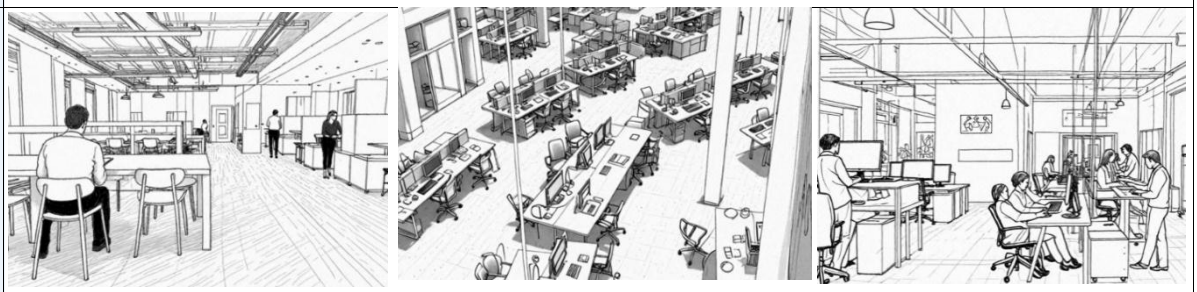
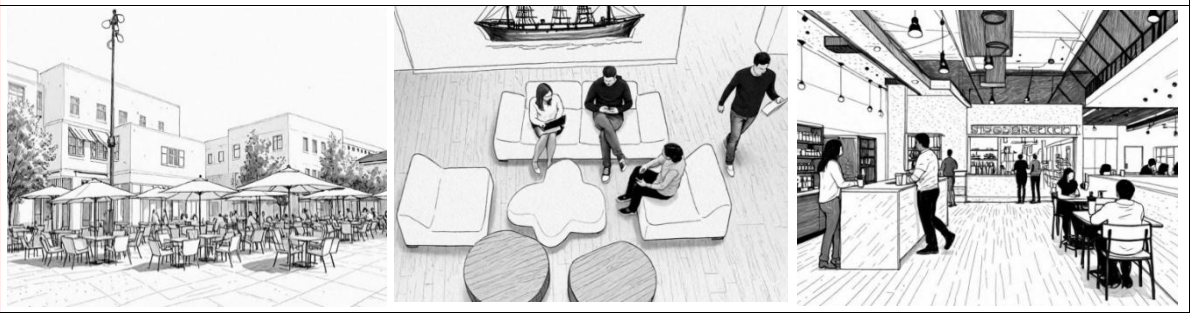
Google Headquarters			
Project definition	**Location**		California, United States
	Year		2005
	Designer		Clive Wilkinson Architects Group
	Type		Internet services
	Description		A complex of twenty buildings with four core buildings that are connected by central courtyards and glass bridges and certified LEED with platinum version. Includes a group of offices and collaborative workspaces that provide powerful and spirited feelings within working hours with various dining options, recreational areas, and a combination of sports fields, and recreational areas.
Biophilic design strategies	Attributes that permit	B01	● The form facilitates access and connectivity between spaces and rooftops with scooter-riding or biking. ● Having a suitable ground surface for navigation Allows using bikes inside the building.
		B02	● Conceive a place for withdrawal, from the main flow of activity, to make the individual feel safe/ under shelter like private offices, reading nooks and covered walkways.
		B03	● Degree of visual transparency and the presence of way finding tools in the scene.
		B04	● Opportunity to refresh during working or break time, by playing basketball, or tennis in an Outdoor space. ● The place provides many enjoyable activities that are compatible with users' desires.
	Photos		
	Attributes that promote restoration	Direct Natural Attributes	B05	● Bring in natural light through high and wide glass walls. ● using daylight preserving window treatments.
			B06	● Encouraging going outside and exposure to natural air by creating outdoor sitting. ● Increase natural ventilation by installing operable windows to reach thermal comfort.
			B08	● Bring vegetation indoors by indoor green walls and potting plants.
			B09	● Provide window views of natural landscapes such as grasslands.
			B10	● Fragrant herbs, flowers, songbirds, natural air, and sun patches. ● Textured materials (stone, wood, and Artificial grass).
		Indirect Natural Attributes	B11	● Present natural scenes, water, or landscapes in photographs, or paintings.
			B12	● Use natural materials wood. ● Use natural colours like green, and other earth colours.
			B13	● Simulate weather conditions such as temperature, and humidity. ● Establishing a balance between dynamic and diffused lighting conditions
			B14	● The designers claim that the ceiling and lighting fixtures are intended to evoke the molecular structure of salt.
		Spa	B15	● Arrange rich complexity details in an orderly manner like gypsum units for ceilings, lighting units, and furniture.

		B19	● The place is organized in its physical arrangement. ● Balance and unity are founded on symmetries, repeated elements, homogeneous textures, or colour patterns.
		B20	● optimize visual access to indoor or outdoor vistas by orienting buildings, corridors, and fenestration. ● Enhance the experience of space by removing visual barriers.
	Photos		
Strategies for wellbeing in workspaces	Functional and physical wellbeing		● Active system by using bikes and scooters to transport between buildings and inside buildings to improve physical health. ● Design gym and healthcare services such as the massage program, which could be rendered by a certified therapist to reduce stress. ● Concentration spaces and reading nooks through elements such as lighting, layout, and types of furniture. ● Every enclosed area is designated with a distinct colour on the ceiling, floor, or glass, creating an atmosphere of seclusion and individuality. ● Gradient the scale of privacy in the workplace from open-plan offices to semi-private and then private workplaces. ● Reducing background noise in the office is significantly reduced by creating clusters by dividing the area with glass walls. ● Using the brand colours of Google in interior and exterior spaces. ● Flexible workplaces by establishing electrical access so that people may work anywhere in the building and offering comfortable furnishings that can be used anywhere. ● The creation of collaborative workplaces and open areas for teamwork.
	Photos		
	Social wellbeing		● Informal outdoor and indoor working spaces that allow workers to connect socially. ● Outdoor recreation center for sports like basketball, and tennis, and indoor rooms full of video games and playing tables ● Designing public spaces like parks and plazas. ● Multi-purpose meeting and event room. ● Several cafés and small open kitchens are distributed in different buildings.
	Photos		

3.2 Facebook Headquarters

Table 3. Sample 2 definition. Source: the authors, based on: [79, 83, 84].

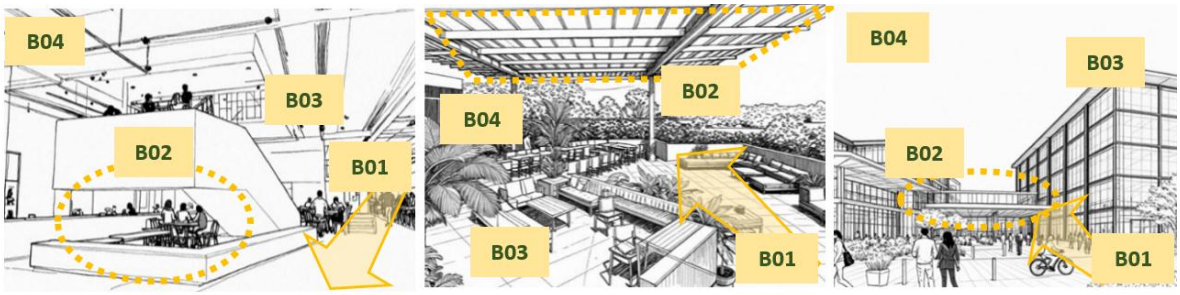
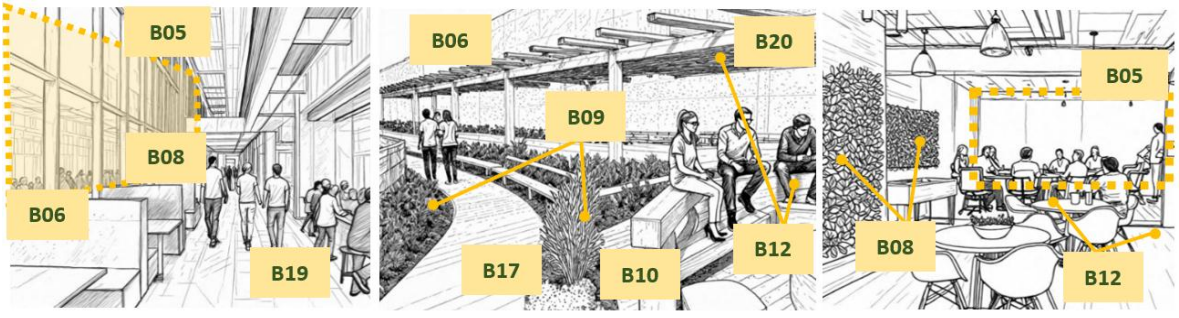
Facebook Headquarters			
Project definition	**Location**		California, United States
	Year		2015
	Designer		Frank Gehry designed the buildings 20 and 21, which are known as MPK 20 and MPK 21.
	Type		Social media
	Description		The company's philosophy is reflected on Facebook's campus: It is socially connected, open, mobile, dimensionally aware, and culturally appropriate. In 2018, Facebook MPK21 received a platinum version certification from LEED.
Biophilic design strategies	Attributes that permit	B01	● Symmetry of repeated elements along an axis. ● Having a suitable ground surface for navigation. ● Wide and smooth hallways and plaza for bikes to access into the building and provide bike parking.
		B02	● Conceive a place for withdrawal from the main flow of activity or environmental conditions to make the individual feel safe or under shelter like an overhead trellis.
		B03	● High degree of visual transparency.
		B04	● The built environment and activities seem to fit together quite naturally. ● The place provides many enjoyable activities like gaming rooms, and gathering area.
	Photos		
	Attributes that promote restoration	Direct Natural Attributes	B0 ● Bring in natural light through glass walls, clerestories, and atria.
			B06 ● Encouraging going outside and exposure to natural air by creating shaded outdoor sittings. ●Increased ventilation and thermal comfort in the buildings.
			B08 ● Design to support a visual connection with surrounding nature. ● Incorporate plants through using green roofs.
			B09 ● Create landscapes on the site, such as an outdoor park and a rooftop garden. ● The use of dense trees around and above the buildings makes the site look like a forest.
			B10 ● Fragrant herbs, flowers, songbirds, and sun patches. ● Different textures, like wood and grass.
		Indir	B12 ● Use natural materials like rock, wood, and stone. ● Use natural colours like green, blue, and other earth colours.
		Space and Place	B17 ● Create winding paths.
			B18 ● Using the relative size of known objects like trees as the metric for size and distance of what lies beyond.
			B19 ● Visual order of scene components, through linkage of scene components, a linear succession of tree trunks.
			B20 ● optimize visual access to indoor or outdoor vistas by orienting buildings, corridors, and fenestration. ● Providing open interior spaces and removing visual barriers.

Strategies for wellbeing in workspaces	Functional and physical wellbeing	● Increase body movement by encouraging using stairs, skateboards, and bikes to transport between buildings and inside buildings to improve physical health. ● Give employees the freedom to express what is on their minds by placing black and white boards in many places. ● Empowers employees with a sense of choice through various spaces for both individual work and group collaboration. ● Spaces with semi-privacy from the main flow of activity through elements such as lighting, layout, and types of furniture. ● Stand-up workstations with treadmills are spread throughout to provide opportunities to stay active during the day. ● Flexible workplaces by establishing electrical access so that people may work anywhere in the building and offering moving furniture that can be used anywhere. ● The creation of open-plan offices results in collaborative workplaces and open areas for teamwork.
	Photos	
	Social wellbeing	● Create informal workspaces inside and outside the buildings that help to get the stress level down. ● Three gyms on Facebook HQ provide premiere fitness equipment that is open to all staff individuals. ● Designing public spaces like plazas and the rooftop garden. Several cafés small open kitchens distributed in different buildings. ● Gaming rooms: giving employees several options to enjoy and creating opportunities for them to collaborate while not officially at their desks engaging in "work.".
	Photos	

3.3 Adobe Headquarters

Table 4. Sample 3 definition. Source: the authors, based on: [79, 85].

Adobe Headquarters Renovation			
Project definition	**Location**		California, United States
	Year		2017
	Designer		Gensler
	Type		Computer hardware and software
	Description		The various areas within the community are intended to boost employees' output and sense of purpose in their workplace. The open floor plan, contemporary architectural design, and interior modelling aim to give employees a motivating work environment. The building is certified LEED with a platinum version.
Biophilic design	Attributes that	**B01**	● The new Adobe tower is linked to the rest of the Adobe buildings by a sky bridge. ● Having a suitable ground surface for navigation.
		B02	● Conceive a place with an overhead trellis to make the individual feel under shelter. ● Provide a space to withdraw from the main flow of activity, like booth seating.
		B03	● Degree of visual transparency and the presence of way finding tools in the scene.

		B04	● The built environment and activities seem to fit together quite naturally. ● The place provides many enjoyable activities like Basketball court and wellness center.
Photos			
		B05	● Bring in natural light through glass walls and atria. ● Avoidance of dynamic lighting conditions such as direct where directed attention activities are performed.
		B06	● Encouraging going outside and exposure to natural air by creating outdoor settings. ● Increase natural ventilation by installing operable windows.
		B08	● Design to support a visual connection with the outdoor environment. ● Bring vegetation indoors by indoor green walls and potting plants.
		B09	● Create landscapes in the sites, such as grasslands and terraces and the rooftop garden. ● Provide window views of natural landscapes
		B10	● Natural ventilation, sun patches.
	Indirect Natural	B11	● Present natural scenes, plants, water, and landscapes in photographs or paintings.
		B12	● Use natural materials like wood. ● Use natural colours like green and other earth colours.
		B14	● evoke natural geometries, forms in tree sculptures, each with a unique spectrum of colour and geometry that invites exploration and discovery.
	Space and Place	B15	● Arrange complexity ceiling and wall details in an orderly manner.
		B19	● Visual order of scene components, through a linear succession of tree trunks or canopies. ● Balance and unity are founded on repeated homogeneous textures and the brand colour pattern.
		B20	● optimize visual access to indoor or outdoor vistas by orienting buildings, corridors, and fenestration. ● Enhance the interior experience of space by removing visual barriers.
Photos			

Strategies for wellbeing in workspaces	Functional and physical	● Through an open and dynamic work environment, Adobe fosters creativity and collaboration for all of its employees. ● Flexible workplaces by offering moving furniture that can be used anywhere. ● To improve employee productivity and satisfaction with their employer, community spaces are designed. ● Empowers employees with a sense of choice through various spaces for both individual work and group collaboration. ● Concentration spaces with high partitions in some seating areas are intended to increase employees' privacy. ● The Adobe fitness center and meditation room have been created with a view of outdoor nature, and the company offered a massage room for workers to relieve stress during working hours.
	Photos	
	Social wellbeing	● There are multiple spaces for gathering and meetings, one of which is a terraced area equipped with bleacher chairs. ● Designing public spaces like plazas and the rooftop garden. ● Create informal workspaces inside and outside the buildings that encourage social relationships among employees. ● Several cafés and learning open kitchens in different buildings. ● Create play and shopping spaces.
	Photos	

4. INNOVATIVE AND PRODUCTIVE WORKSPACE SUPPORTING RESTORATION

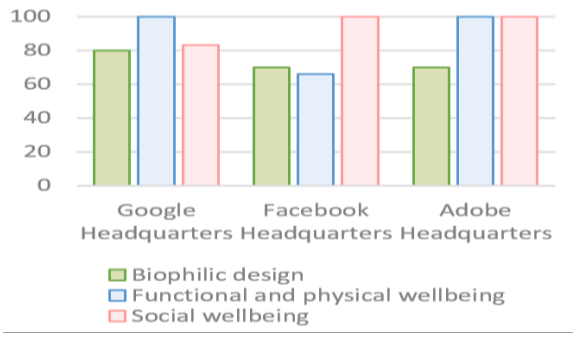
Attempting to apply this information as measurable criteria, analysing and utilizing the findings of the case studies can lead to a more successful, effective experience. This study narrowed the information into several common biophilic design attributes or well-being characteristics that largely affect the design of an innovative and productive workspace that supports restoration.

4.1 Characteristics for Wellbeing in Workspaces

To create productive workplaces, we must design a strategy that supports and enables efficient, happier, and healthier employees. Biophilic design strategies support the psychological restoration of employees. The other influential characteristics: functional well-being and social well-being must be studied alongside biophilic design to achieve psychological restoration in the workspace [86]. Therefore, it is important to get the characteristics depending on these two categories to have insight into the research necessity and find out the strategies that big companies use.

4.1.1 Functional and Physical Characteristics

It refers to those characteristics that support employees to perform their jobs in the workplace in the best possible way to reach the highest levels of productivity, which are: **FW1-** Productivity and satisfaction, **FW2-** Flexibility, **FW3-** Privacy, **FW4-** Creativity and



Collaboration, **FW5-** Concentration and reducing noise, and **FW6-** Encouraging activity and movement [19].

4.1.2 Social Characteristics

Having a strong social support network provides employees with a sense of belonging, understanding, and comfort, which can act as a buffer against the challenges and pressures they may face during their daily work routine [87]. Social characteristics refer to those characteristics that encourage employee gatherings and participation and enhance social relations in the workplace, which are: **SW1-** Gathering, **SW2-** Informal working, **SW3-** Meeting and celebration, **SW4-** Enjoyment and playing, **SW5-** Relaxation and restoration, and **SW6-** Providing food services [19].

Figure 3: percentages of attributes and characteristics for supporting restoration in previously described samples. Source: the authors.

Table 5. Analysing of attributes and characteristics for supporting restoration in workspaces. Source: the authors.

	Biophilic design attributes																			Characteristics for wellbeing in workspaces										
	Attributes that permit restoration				Attributes that promote restoration															Functional and physical wellbeing						Social wellbeing					
					Direct Natural Attributes						Indirect Natural Attributes				Space and Place Attributes																	
	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	FW1	FW2	FW3	FW4	FW5	FW6	SW1	SW2	SW3	SW4	SW5	SW6
Google	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Facebook	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓
Adobe	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✗	✓	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

To develop an effective work environment that supports the psychological restoration of its employees, it is important to understand the characteristics of the main workspaces. Therefore, the next section will examine the main spaces of work environment and the users' activities in each space.

4.2 Main Spaces and Types of Activities in the Work Environment

The main workspaces were interpreted as four work modes: collaborating, focusing, learning, and socializing, Gensler asserted that the four work styles are highly interdependent [88, 89]. Concurrently, based on the analysis of previous case studies, this study divides the spaces in the work environment into four main spaces:

Formal workspaces: Separate workspaces to focus, generate ideas, and communicate with colleagues to exchange ideas, learn, and create even better ones [90].

Informal workspaces: The open-floor offices or meeting rooms for informal working, to foster greater collaboration is a major driving force behind the informal workspaces trend. Today's top executives in many companies think that teamwork is essential to raising employee productivity [90].

Gathering spaces: The socializing work environment with an opportunity to improve gathering, engage employees, and drive innovation and the productive spread of ideas [91].

Relaxing and taking break spaces: The spaces dealing with depression and stress at work like relaxation areas for breathing exercises, yoga, meditation, massages, and rhythmic exercises [92, 93].

Gehl's classification of outdoor activities in public spaces can be used to determine concluded activities in workspaces. He categorizes activities into three groups, all of which have distinct demands on the environment [94]. Subsequently, activities within workspaces can be categorized and defined into:

Necessary Activities: will happen regardless of the space's condition. An example would be working and meeting in the work environment [94].

Optional Activities: These are dependent on the built environment attributes; they will happen when the space lends itself to them and the conditions are encouraging. An example would be reading, sitting, relaxing, or taking a break [94].

Social Activities: likewise dependent on the surrounding built environment attributes, but more essentially, the presence of people, which in turn is dependent on the built environment, like playing, gathering, and doing communal activities.

It is these optional and social activities that create lively space in the context of the work environment and maximum opportunity for informal working to take place. Therefore, workspace activity types will be stated accurately in (Table 6) to perform actual scheduling to the relation between users' activities and types of activities in each space in the work environment.

Therefore, the next section will study and analyse the relationships between each space in the work environment, each attribute of biophilic design, and each characteristic of functional and social well-being for employees.

4.3 The Relationships between Biophilic Design Attributes Well-being Characteristics and Each Workspace

To identify the biophilic attributes and well-being characteristics that support employees' restoration associated with each workspace, Table 7 illustrates the relationships between each workspace and the biophilic attributes and well-being characteristics.

Table 6. The main activities in the different spaces in the workplace. Source: the authors.

Necessary / Optional / Social / Non-relationship	Working	Learning	Meeting	Talking	Reading	Gathering	Celebrating	Relaxing	Sleeping	Playing	Eating	Viewing nature
Formal Workspaces	●	●	●	○	◑	○						◑
Informal Workspaces	●	●	●	○	◑	○	○	◑		◑	◑	◑
Gathering Spaces	◑	◑	◑	○	◑	○	○	◑	◑	◑	◑	◑
Relaxing and Taking Break Spaces	◑	◑	◑	○	◑	○	○	◑	◑	◑	◑	◑

5. PROPOSED GUIDING MODEL

5.1 strategies of Implementation

After setting the biophilic attributes, the study determines strategies for incorporating each attribute in the work environment based on the reviewed literature and analysis of the case studies (Table 8).

As explained in the previous analysis in Table 6, each space in the work environment differs in biophilic attributes and well-being characteristics associated with the restoration according to its use. Consequently, the designer will identify the attributes and characteristics affecting restoration which will be included in the evaluation of the workspace, based on Table 6.

5.2 Weights, Scores, and Rates

- In this context, each strategy will be evaluated using a score; very satisfied +3, satisfied +2, dissatisfied +1, and non-existent 0.
- Some strategies are interchangeable, so it is not necessary to achieve both. Achieving one of them gives a score in the evaluation (they show in the guiding model with "OR" between them). Therefore, they will be combined in the evaluation to form one score.
- Biophilic attributes are the main attributes affecting restoration, while well-being characteristics are less influential. Therefore, the research assumed that a BD attribute has a higher relative weight (RW) than a FW or SW characteristics [17, 95].

5.3 Method of Evaluation

Based on the previous discussion, the evaluation method can be formulated as shown in (Figure 4).

1- The average score is calculated for each BD attribute or FW or SW characteristics.

2- The rate % of each BD attribute, FW, or SW characteristics assessment will be calculated based on RW.

3- The overall restoration value of BD, FW, or SW. will be calculated by the sum of rates.

4- In addition, the sum of the restoration values for BD, FW, and SW gives the total restoration value of the workspace then the overall restoration value.

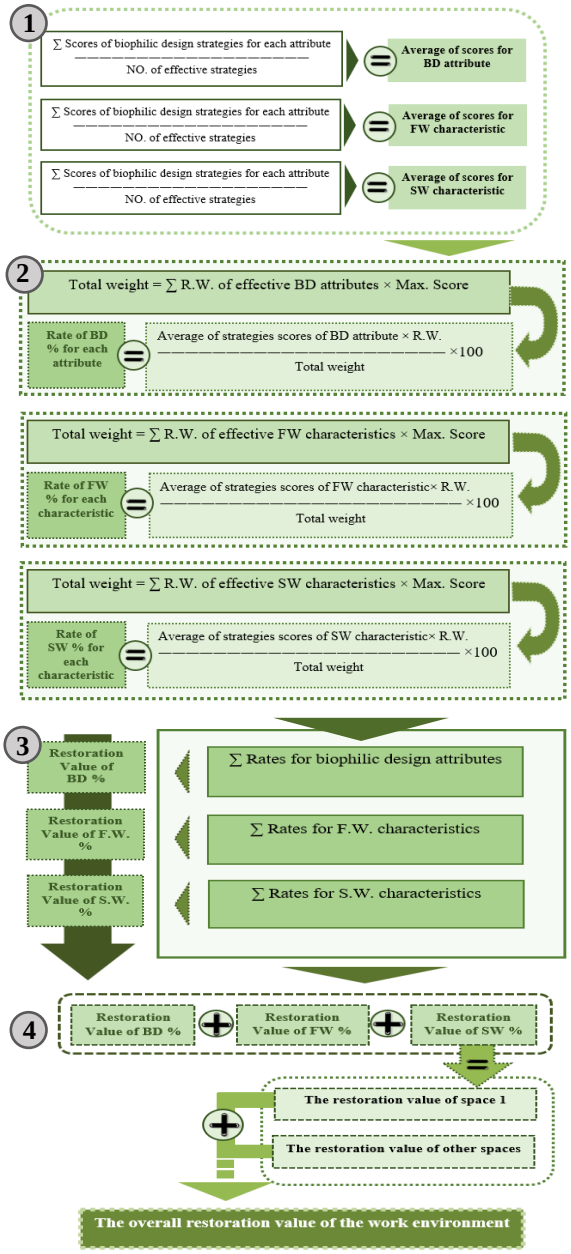


Figure 4: Illustration of the evaluation method. Source: the authors.

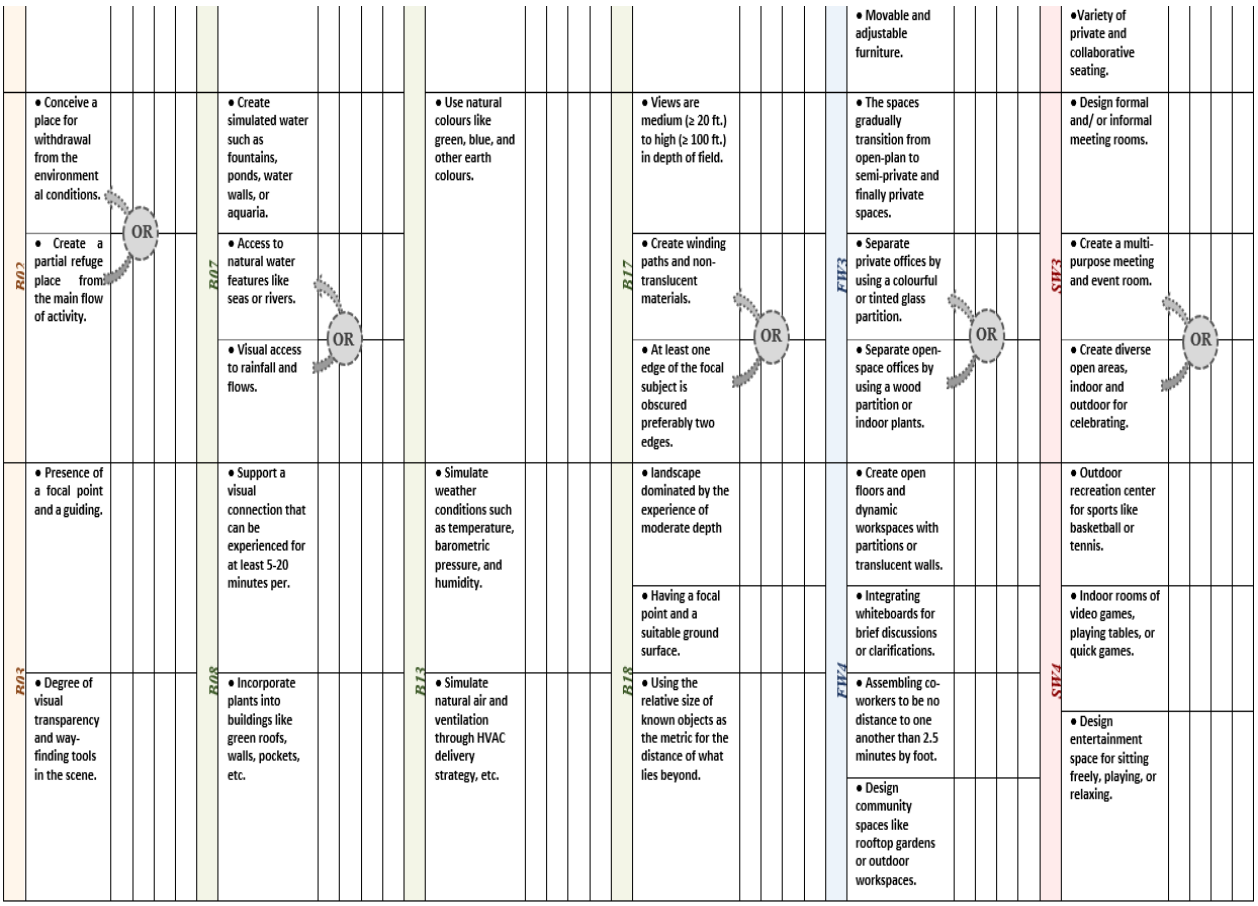
Consequently, Table 8 shows the proposed guiding model for the workspaces to improve the psychological restoration in each space into the work environment.

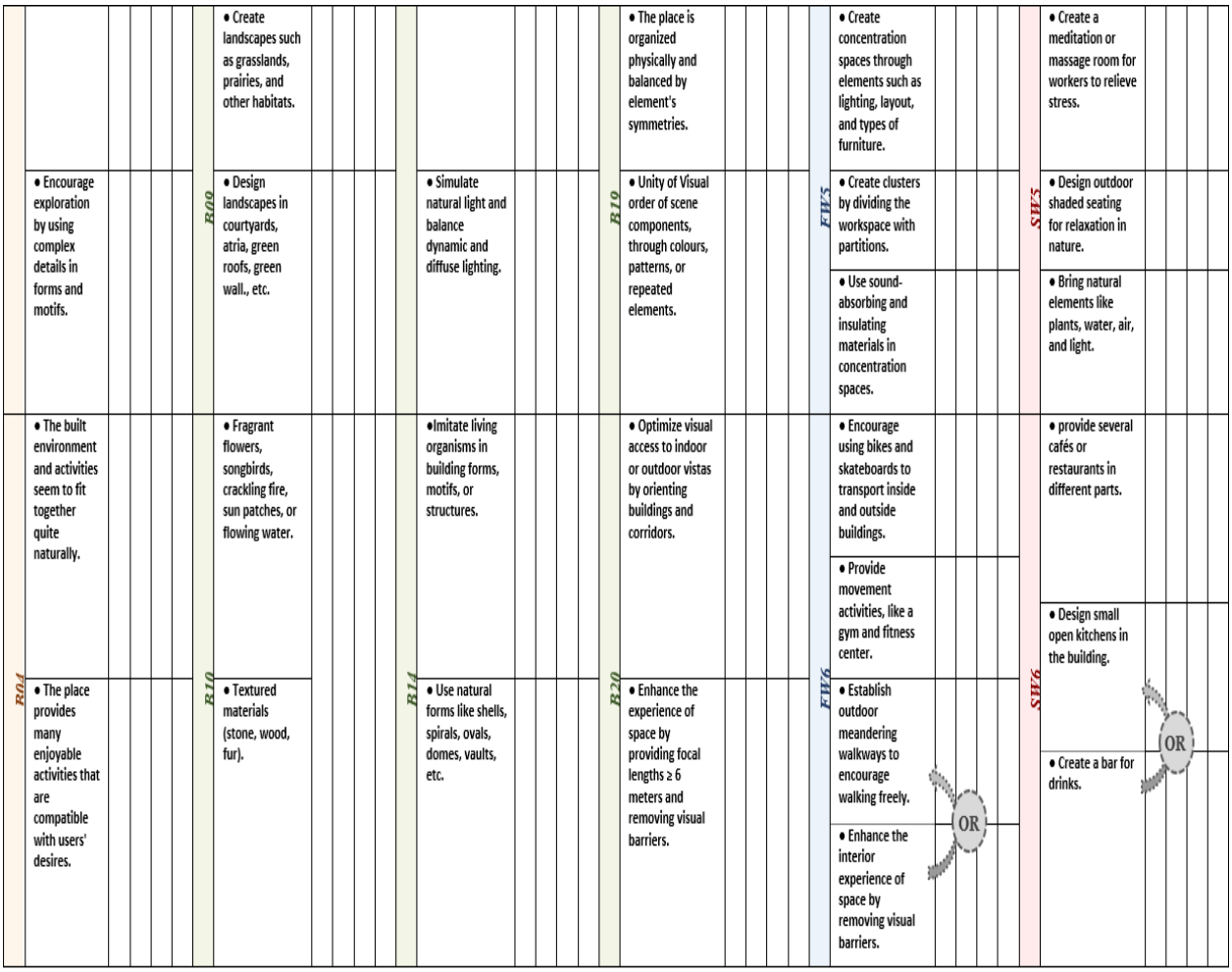
Table 7. Specific biophilic design attributes and wellbeing characteristics for each workspace. Source: the authors.

	Biophilic design attributes																		Characteristics for wellbeing in workspaces											
	Attributes that permit restoration				Attributes that promote restoration														Functional and physical wellbeing						Social wellbeing					
					Direct Natural Attributes						Indirect Natural Attributes				Space and Place Attributes																	
	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	FW1	FW2	FW3	FW4	FW5	FW6	SW1	SW2	SW3	SW4	SW5	SW6
Formal Workspaces	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✓	✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗
Informal Workspaces	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗
Gathering Spaces	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✗	✗	✓
Relaxing and Taking Break Spaces	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓

Table 8. The proposed guiding model. Source: the authors.

Biophilic design attributes																						Well-being Characteristics										
Attributes that permit restoration						Attributes that promote restoration																Functional well-being						Social well-being				
						Direct Natural Attributes						Indirect Natural Attributes					Space and Place Attributes															
Attributes	Biophilic design strategies	Very Satisfied	Satisfied	Dissatisfied	Non-Existent	Attributes	Biophilic design strategies	Very Satisfied	Satisfied	Dissatisfied	Non-Existent	Attributes	Biophilic design strategies	Very Satisfied	Satisfied	Dissatisfied	Non-Existent	Attributes	Biophilic design strategies	Very Satisfied	Satisfied	Dissatisfied	Non-Existent	Characteristic	Wellbeing design strategies	Very Satisfied	Satisfied	Dissatisfied	Non-Existent	Characteristics	Wellbeing design strategies	Very Satisfied	Satisfied	Dissatisfied	Non-Existent
B01	• Provide views of prominent landmarks or landscapes.					B05	• Bring in natural light through glass walls, skylights, etc.					B11	• Present natural scenes, animals, plants, water, or landscapes in photographs or paintings.					B15	• Arrange rich and complex details in an orderly manner.					FW1	• Having a variety of workspaces (individual, collaborative, formal, informal)					SW1	• Designing public spaces like parks, plazas, or rooftop gardens.				
							• Using daylight-preserving window treatments in workspaces.												• Evoke natural geometry, forms, and patterns.						• Create stand-up workstations.						• Design courtyards with conversation areas to facilitate gatherings.				
							• Avoidance of direct sunlight and high contrasts in workspaces.						OR • Present images include human survival experiences in nature.						• Using duplicate materials or colours to arrange the various details.						•Using natural light and ventilation in the workspaces.						• create an amphitheatre-style space with staggered seating levels.				
	• Symmetry of repeated elements along an axis					B06	• Installing operable windows, vents, etc. to reach thermal comfort.					B12	• Use between 30 and 45 percent natural materials like rock, wood, stone, etc.					B16	• Use hierarchical organized ratios, fractions , and scales in designs.					FW2	• Allow users to control temperature and lighting.					SW2	• Provide enough lighting and power outlets for laptops.				
							OR • Encouraging going outside and exposure to natural air.												• Choose the intermediate ratio (1:1.3e1.75).						•Establishing electrical access everywhere so users can work anywhere.						• Comfortable and flexible pieces of furniture inside and outside the building.				
	• Having a safe space from which to plan a route.						• Incorporate airflow and thermal conditions into materials.												OR • Use the Golden Ratio (1:1.618) or Fibonacci series (0, 1, 1, 2, 3, 5, 8, 13, 21, 34).						• Allow users to control their privacy through adjustable blinds and privacy screens.										


• Movable and adjustable furniture.
•Variety of private and collaborative seating.
B02
• Conceive a place for withdrawal from the environmental conditions.
OR
• Create a partial refuge place from the main flow of activity.
B07
• Create simulated water such as fountains, ponds, water walls, or aquaria.
• Access to natural water features like seas or rivers.
OR
• Visual access to rainfall and flows.
• Use natural colours like green, blue, and other earth colours.
B17
• Views are medium (≥ 20 ft.) to high (≥ 100 ft.) in depth of field.
• Create winding paths and non-translucent materials.
OR
• At least one edge of the focal subject is obscured preferably two edges.
FW3
• The spaces gradually transition from open-plan to semi-private and finally private spaces.
• Separate private offices by using a colourful or tinted glass partition.
OR
• Separate open-space offices by using a wood partition or indoor plants.
SP3
• Design formal and/ or informal meeting rooms.
• Create a multi-purpose meeting and event room.
OR
• Create diverse open areas, indoor and outdoor for celebrating.
B03
• Presence of a focal point and a guiding.
• Degree of visual transparency and way-finding tools in the scene.
B08
• Support a visual connection that can be experienced for at least 5-20 minutes per.
• Incorporate plants into buildings like green roofs, walls, pockets, etc.
B13
• Simulate weather conditions such as temperature, barometric pressure, and humidity.
• Simulate natural air and ventilation through HVAC delivery strategy, etc.
B18
• landscape dominated by the experience of moderate depth
• Having a focal point and a suitable ground surface.
• Using the relative size of known objects as the metric for the distance of what lies beyond.
FW4
• Create open floors and dynamic workspaces with partitions or translucent walls.
• Integrating whiteboards for brief discussions or clarifications.
• Assembling co-workers to be no distance to one another than 2.5 minutes by foot.
• Design community spaces like rooftop gardens or outdoor workspaces.
SP4
• Outdoor recreation center for sports like basketball or tennis.
• Indoor rooms of video games, playing tables, or quick games.
• Design entertainment space for sitting freely, playing, or relaxing.


• Create landscapes such as grasslands, prairies, and other habitats.
B09
• Encourage exploration by using complex details in forms and motifs.
• Design landscapes in courtyards, atria, green roofs, green wall., etc.
• Simulate natural light and balance dynamic and diffuse lighting.
B19
• The place is organized physically and balanced by element's symmetries.
• Unity of Visual order of scene components, through colours, patterns, or repeated elements.
FW5
• Create concentration spaces through elements such as lighting, layout, and types of furniture.
• Create clusters by dividing the workspace with partitions.
• Use sound-absorbing and insulating materials in concentration spaces.
SP5
• Create a meditation or massage room for workers to relieve stress.
• Design outdoor shaded seating for relaxation in nature.
• Bring natural elements like plants, water, air, and light.
B04
• The built environment and activities seem to fit together quite naturally.
• The place provides many enjoyable activities that are compatible with users' desires.
B10
• Fragrant flowers, songbirds, crackling fire, sun patches, or flowing water.
• Textured materials (stone, wood, fur).
B14
•Imitate living organisms in building forms, motifs, or structures.
• Use natural forms like shells, spirals, ovals, domes, vaults, etc.
B20
• Optimize visual access to indoor or outdoor vistas by orienting buildings and corridors.
• Enhance the experience of space by providing focal lengths ≥ 6 meters and removing visual barriers.
FW6
• Encourage using bikes and skateboards to transport inside and outside buildings.
• Provide movement activities, like a gym and fitness center.
• Establish outdoor meandering walkways to encourage walking freely.
OR
• Enhance the interior experience of space by removing visual barriers.
SP6
• provide several cafés or restaurants in different parts.
• Design small open kitchens in the building.
OR
• Create a bar for drinks.

6. CONCLUSION

This paper highlighted incorporating biophilic design in the work environment to support psychological restoration for employees. The biophilic design framework was applied to three global workspaces to identify the design strategies to support employees' restoration. It was revealed that biophilic design's direct natural attributes have the greatest impact on supporting psychological restoration. Specifically, large windows should be provided in the working spaces to optimize the provision of natural air and light and maximize visual connection with nature. Where direct contact with nature is impossible, exposure to indirect natural attributes, such as images of nature, stimulating natural attributes, and natural materials and colours, can compensate. In addition, other strategies that influence restoration in the work environment are associated with functional and social well-being thus the study proposed functional and social well-being characteristics like productivity, privacy, flexibility, and gathering and recreation spaces.

According to this study, to develop an effective work environment that supports the psychological restoration of its employees, the main spaces in the work environment are divided according to the nature of the spaces and the activities that take place in them into 4 types: formal, informal, gathering, and relaxation spaces. Therefore, it can be observed that formal workspaces have no relation with social well-being characteristics, and informal workspaces have no relation with some social well-being characteristics such as playing, relaxing, and providing food services. Furthermore, the study determined the effective attributes and characteristics of each workspace and then illustrated the strategies of implementation and the method of evaluation in the guiding model. The main contribution of this study has been to submit the guiding model with strategies to support psychological restoration, which has provided a deeper insight to help designers incorporate and evaluate biophilic attributes and well-being characteristics into the work environment.

Thus, this study lays the groundwork for future research to extend the investigation into the results of the application of the guiding model to different kinds of workspaces in future studies and the effect of incorporating biophilic design on other aspects like behaviour, health, productivity, and the environment by applying the biophilic guiding model. The suggested guiding model and application could be used in more empirical research on various facilities and building types (commercial, educational, and healthcare buildings). More studies could examine the Integration of biophilic design strategies in building rating systems. The impact of alternative design strategies on the psychological restoration factors could be examined in more detailed studies. In addition, future analyses should consider the users' opinions about the space and its strengths and weaknesses through surveys or interviews. Future analyses should consider the potential effects of culture and users' personal preferences on psychological restoration. In addition, promising applications of the guiding model would be important for policymakers to encourage companies to exploit biophilic design and well-being strategies to improve psychological restoration, thus achieving higher productivity rates.

In conclusion, our investigations into this approach are still ongoing, as this study was challenging from the architectural point of view. Further experiments are required to evaluate the psychological impact of integrating these strategies into diverse spaces. More studies could examine the influence of applying the biophilic guiding model on other aspects like behaviour, health, productivity, and the environment. The suggested guiding model and application could be used in more empirical research on various facilities and building types (commercial, educational, and healthcare buildings). More studies could examine the Integration of biophilic design strategies in building rating systems. The impact of alternative design strategies on the psychological restoration factors could be examined in more detailed studies. Future analyses should consider the potential effects of culture and users' personal preferences on psychological restoration.

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