

Occupational Stress and Workplace Design

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Abstract: The World Green Building Council (WGBC) advocates improvements in employee health, wellbeing, and productivity in buildings as people are about 90% of an organisation's expense and well exceed building costs and energy costs. It was reported that earlier research on workplace design primarily focused on physical arrangement of employees' immediate work area, and ambient environmental qualities of the work area. Building organisation, exterior amenities, and site-planning have been given less attention. Therefore, we examine more closely the health relevance of both proximal and remote aspects of workplace design. Occupational stress is a complex phenomenon that is dynamic and evolving over time. This investigation reviews the existing fundamental conceptual models of occupational stress, workplace design, and connection to nature. It aims to develop an improved model relevant to work place design and occupational stress linked with connection to nature. The proposed improved model is presented with an appropriate causal loop diagram to assist in visualizing how different variables in a system are interrelated. The developed model highlights how connection to nature in workspaces can function as a work resource with a dual effect of improving physical wellbeing and psychological wellbeing.

Keywords: occupational stress; workplace design; connection to nature; wellbeing; causal loop diagram

1. Introduction

The World Green Building Council (WGBC) provides a compelling business case argument for health, wellbeing, and productivity: "people are 90% of an organisation's expense and well exceed building costs and energy costs, therefore, a small improvement in employee productivity can yield significant value." [1] (p. 2). The relationships between workplace design and occupational health were examined by Stokols (2011) [2], who reported that they are considered at several levels of analysis:

1. Physical arrangement of employees' immediate work area,
2. Ambient environmental qualities of the work area,
3. Physical organization of buildings that comprise a particular workplace,
4. Exterior amenities and site planning of those facilities.

Stokols (2011) [2] found that workplace design levels 1 and 2 were the primary areas of focus of earlier research, while level 3: building organisation and level 4: exterior amenities and site-planning have been given less attention. Stokols (2011) [2] recommended a thorough examination of the health relevance of both proximal and remote aspects of workplace design in future research. In this paper, we examine more closely the connection to nature and wellbeing aspects of workplace design.

Based on survey data, Higginbottom (2014) [3] reported that employees suffering from high stress levels have lower engagement, are less productive, and have higher absenteeism levels than those not working under excessive pressure. Occupational stress is a complex phenomenon that is dynamic and

evolving over time. The traditional study designs for occupational stress have been statistical tests. To better capture the underlying dynamic processes including feedbacks and delays, system dynamics (an analytic method) is more appropriate. This investigation reviews the existing conceptual and system dynamics models of occupational stress. None of them include the connection to nature aspect, even though positive health effects of this aspect have been documented in biophilic design literature. It aims to develop an improved model relevant to work place design and occupational stress linked with connection to nature. The proposed improved model is presented with an appropriate causal loop diagram to assist in visualizing how different variables in a system are interrelated.

The World Health Organization (2007) [4] (p. 4) defined work-related stress as “a pattern of reactions that occurs when workers are presented with work demands not matched to their knowledge, skills, or abilities and that challenge their ability to cope”. This is similar [5] to the most cited definitions of occupational stress by the National Institute for Occupational Safety and Health (NIOSH) [6]. One of the conceptual models of stress, the Job Demands–Resources (JD–R) model [7], presented in Section 2, aligns well with these definitions. Hobfoll (2002) [8] categorised resources into four types: status resources, material resources, social resources, and personal resources. The Conservation of Resources (COR) theory by Hobfoll (1989) [9] emphasized resources that may be categorised into personal (mental, physical, and social) and job-related. In this investigation, we apply the COR theory [9] and combine it with the JD–R model [7] to explain the mechanism by which a job resource of having a work environment, which enable connection to nature, can reduce stress, which in turn alleviates the negative effect of a high job demand situation.

In particular, the combined JD–R model and COR model is used to show that having an environment, which enable connection to nature, has a positive effect on organizational outcomes.

The reasons are as follows:

1. Physical resource that can directly promote wellbeing. Some may argue that green natural environments are a physical resource.
2. No direct relation to condition or personal characteristics.
3. Energies—seen as value in aiding the other type of resources. Especially, it is seen as an aid to maximizing the use of relevant personal traits in that it promotes concentration and a sense of awareness.

The main aim of this review is to propose an improved conceptual model that incorporates three themes: wellbeing, workplace design, and connection to nature. Two innovative aspects of the improved model are the following: (1) it includes nature as a resource or a pre-requisite in workplace design; (2) it explains the mechanism of how these three themes are connected.

2. Method

The existing fundamental conceptual models of occupational stress (Job Demands–Control (JD–C) model, Job Demands–Resources (JD–R) model, and Conservation of Resources (COR) model), and workplace design, connection to nature, and biophilic design were reviewed. Literature searches were conducted using Web of Science [10] for the time span between 1900 and 2018 on the core database. It should be noted that the review is based on literature published in English only. The numbers of documents found for various combinations of keywords are shown in Table 1.

Table 1. Web of Science search results.

No.	Search Terms	Result
1	"Job demands–control model"	48
2	"Job demands–resources model"	419
3	"Conservation of resources model"	33
4	"workplace design"	387
5	"connection to nature"	97
6	"biophilic"	162
7	"Job demands–control model" AND "connection to nature"	0
8	"Job demands–resources model" AND "connection to nature"	0
9	"Conservation of resources model" AND "connection to nature"	0
10	"workplace design" AND "connection to nature"	0

From the results of the literature search, a mix of highly cited papers and recent papers were selected for review with a focus on the models' strengths and limitations. The next section presents the conceptual models found in the literature. Based on the findings of the review, we proposed a modified occupational stress model that considers connection to nature as a resource in Section 5.

3. Conceptual Models on Occupational Stress

Research over the years has shown that job characteristics influence an employee's wellbeing [7,11–14]. High work pressure and job demands may lead to negative health outcomes such as high blood pressure, headaches, indigestion, and insomnia [15]. On the other hand, the provision of adequate job resources can help employees with a high demand job environment and can help alleviate the risk imposed by the demands of any job [16,17]. The nature of job resources is also a topic that needs detailed examination as these are not restricted to characteristics of the work environment and may include personal resources such as resilience, ability to cope with stress, and stress coping behaviours [9]. Recent research also showed that personal characteristics influence organizational outcomes [13,14,18]. In the following sections, we present some of the early classic work design research on job demands and job control models, job demand and resources model, and the inclusion of personal characteristics in these models. This early research has been developing over the years and lays the important foundation framework to explain the relationship of work design to employee wellbeing. The importance of personal characteristics in dealing with the job demands are also important in determining the level of contribution to organizational outcomes [18].

3.1. Job Demands–Control (JD–C) Model in Classic Work Design Theory

Karasek's Job Demands–Control (JD–C) model [11] is the earliest and most cited model that relates work design to occupational stress [19]. In the Job Demands–Control model, the ability to control a piece of work would alleviate the negative effects of job demands. It also helps enhance employees' job satisfaction and engages them in more challenging tasks and jobs requiring higher-level skillsets [11]. In the JD–C model (Figure 1), Karasek [11] postulated that in regards to labour intensity, the work environment has an effect on health promotion (reduces work strain). On one hand, the level of work strain or job demands includes requirements such as work rate, time allocated, the anticipated pressure to complete a task, effort, and relative difficulty. Such requirements contribute to the psychological stressors in the work environment. On the other hand, the level of control afforded by the workplace, also known as job decision latitude, determines the freedom that an employee has in initiating, organizing, executing, and controlling his own work. This job decision latitude refers to the control that employees have in going about their duties and the manner in which the tasks are performed [20]. It concerns both the employee's internal resource of competence and an external factor such as the decision-making authority.

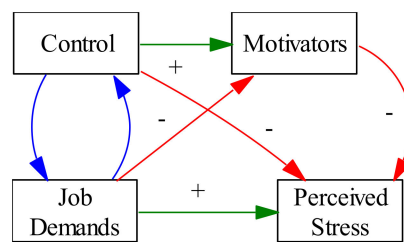


Figure 1. Job Demands–Control (JD–C) model (adapted from Wallgren and Hanse, 2007 [21]). Note: blue arrows indicate co-varying determinants, green arrows indicate positive causal relations, and red arrows indicate negative causal relations.

One important managerial requirement of the JD–C model is the need to have a balance for job autonomy and work stress, as Karasek [11] postulated that employees in high demand jobs would experience high stress if they cannot decide how to manage the work. The element of control would cause employees far less stress than if they had no control at all. This is especially true when employees have to work within given time schedule or budget constraints. High work pressure coupled with low amount of control would increase the risk of stress. Although the JD–C is simplistic in that it attempts to link psychological fatigue or work stress to two elements of job demands, namely level of autonomy and control, it lays the groundwork to offer insights into the types of managerial interventions that may be possible.

Some researchers cited inconsistencies in the results obtained with the Job Demands–Control model [19,22]. One common explanation was that different variables have been used to measure demands, control, and strain, and more importantly, they do not take workers’ personal characteristics into account [22].

3.2. The Job Demands–Resources (JD–R) Model

Research has shown that job characteristics influence an employee’s wellbeing. High work pressure and job demands may lead to health problems such as high blood pressure and insomnia. On the other hand, the provision of adequate job resources can help employees in a high demand job environment and can help alleviate the risk imposed by the demands of any job. Over the years, researchers made attempts to improve on the JD–C, adding to the model with useful constructs such as resources, burnout, self-efficacy, and social support [12,23–25]. The Job Demands–Resources (JD–R) model is recognized as one of the leading job stress models. A reason for this, as explained by Schaufeli and Taris (2014) [26], is that it is more flexible and can be tailored to a much wider variety of work settings.

The JD–R model [12] focused on the effects of resources–demand on employee burnout using Maslach’s burnout inventory of exhaustion, cynicism, and self-efficacy. Later research moved the focus towards employee disengagement and engagement and this had wider managerial implications for organizational effectiveness. Potentially, it includes all job settings and job environments. The JD–R model presented by Bakker and Demerouti in 2007 [7] explains how these two concepts of job demands and job resources interact to produce strain and motivation, respectively, in determining organizational outcomes (Figure 2). Job demands refer to those physical, psychological, social, or organizational requirements of the job and job resources refer to those physical, psychological, social, or organizational enablers of the job. Job demands can lead to strain, which in turn is negatively correlated with organisation outcomes. Job resources are negatively correlated with job demands and positively correlated with motivation and organizational outcomes.

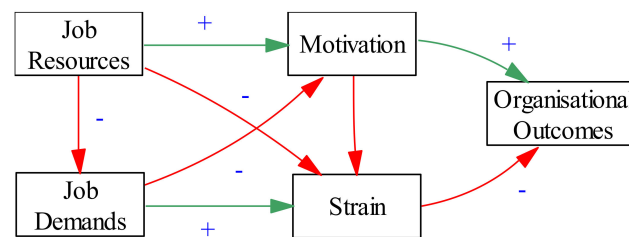


Figure 2. The Job Demand–Resources (JD–R) model (adapted from Bakker and Demerouti, 2007 [7]).
Note: green arrows indicate positive causal relations, and red arrows indicate negative causal relations.

The JD–R model theorises that organizational outcomes are dependent on the motivation and mental wellbeing (here represented as strain), which in turn stems from a balance of positive aspects (job resources) and negative aspects (job demands) of job characteristics. Researchers have also applied these to a variety of settings including longitudinal settings, varying sample sizes, and different types of work environments. In a study of 342 hospitality workers working in 120 work units comprising 60 hotel front desks and 60 restaurants, Salanova, Agut, and Peiro (2005) [27] examined the service climate and employee work engagement and found these to be linked to employee performance and customer loyalty. In 2013, Hui [18] investigated 230 workers in the manufacturing sector in Australia and linked employee engagement, appropriate goal orientation, and the need for achievement to innovative behaviour at work. The presented results [18] suggest that providing work units with organizational resources increased collective work engagement, which in turn helped foster an excellent service climate and performance. A Finnish study of dentists in 2014, by Hakanen and Koivumaki [28], found work engagement was positively associated with the amount of procedure fees and consequently with dentists’ pay level. However, exhaustion was not correlated with productivity. In a longitudinal study of 274 Spanish secondary school teachers, Llorens-Gumbau and Salanova-Soria (2014) [29] found the difficulty of the task (job requirements) is positively related to burnout, which in turn is negatively related to self-efficacy. Likewise, enablers such as resources are positively related to engagement and self-efficacy. As suggested in the JD–R model, good organizational outcome is a result of the mediating effects of good mental health on job demands and the mediating effects of motivation on job resources.

3.3. Stress and the Conservation of Resources (COR) Model

While the relationships between job resources and strain in the JD–R model are clear, Hofoll (1989) [9] presented an explanation for conceptualizing stress (or work strain) using a resources concept. While recognising that there are different views of stress such as the physical view of stress, a stimulus view, or an event perspective of stress, and that there are problems associated with these, Hofoll (1989) [9] suggested that stress results from the net gain or loss of resources and that people have four types of resources they work with in their everyday lives. This model (Figure 3) explains behaviour that people retain, protect, and build resources. Psychological stress would result from (a) a threat or a net loss of resources, (b) the net loss of resources, and (c) net loss after or a lack of gain after investment of resources [30]. Hofoll (1989) [9] said that perceived and actual losses are both valid sources of strain.

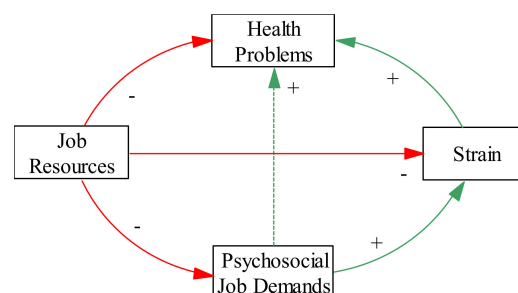


Figure 3. The Conservation of Resources (COR) model (adapted from Mayerl et al., 2016 [14]).
Note: green arrows indicate positive causal relations, and red arrows indicate negative causal relations.

According to the COR model, there are four types of resources [9]. An object (physical) resource has some useful physical characteristics that would directly affect the ability of a person to work. It also has value because it indicates status such as a home or a luxury car. The second type of resource is a condition such as marital status, tenure, seniority, graduation, and so on. This type of resource is sought after because it provides promise for future jobs. The third type of resource is personal characteristics such as traits, skills, and abilities. This directly affects a person's ability to resist stress [31]. The last type of resource is energy, which refers to the intrinsic values of a person such as time or support, for example, having a large social network. Wellman (1981) [32] found that having a large social network contributed to the energies of a person. The COR model suggests that people react to stressful situations (loss or potential loss of resources) by employing other resources to offset the loss. Symbolic replacement may also replace direct replacement. The model suggests that people are motivated by the net gain of resources and may put up with temporary stressful states to gain resources. The COR model is useful in that it offers an insight into resources and strain and what motivates people to use resources to overcome strain.

3.4. Incorporating the COR in the JD–R Model

The JD–R model considered that the job resources were very much a part of the work environment. However, researchers such as Mayerl et al. (2016) [14] have argued that human behaviour comes as a result of people's interaction with the physical environment. Personal resources are normally associated with qualities such as resilience and usually enable a person to control his physical environment. Mayerl et al. (2016) [14] found that personal resources can be used in directing activities to improve wellbeing, as well as influence the perception of job characteristics. They posit that personal characteristics should not exist separately and should be part of the resources available to an employee.

Mayerl et al. (2016) [14] considered that the JD–R model overemphasized the environment external to the individual and neglected the individual and personal characteristics such as energy level, time, or resilience. Making use of Hobfoll's (2003) [33] COR model, which defines qualities such as resilience and optimism into four types of personal resources, Mayerl et al. (2016) [14] went on to develop an integrated model that shows how personal resources can attenuate negative effects of high job demands. The combined model recognises Hobfoll's (1989) COR theory [9], in how people strive to preserve their resources and resources do not exist in isolation, as well as in how people build resources to generate other resources. Individuals high in personal resources are also able to create resources, resulting in a high resource environment [13,34]. Mayerl et al.'s (2016) [14] model combines both job and personal resources to a common resources factor and linked this factor to the health-impairment process of the JD–R model. Mayerl and his team [14] surveyed 8657 participants from the Austrian working population and found that job and personal resources can be considered as indicators of a single resources factor, which was negatively related to psychosocial job demands, mental strain, and health problems. Confirming previous studies, they further found that mental strain mediated the relationship between psychosocial job demands and health problems. Their findings suggest that interventions aimed at maintaining health in the context of work may act on three levels: (1) the prevention of extensive job demands, (2) the reduction of work-related mental strain, and (3) the strengthening of resources.

3.5. The Importance of Creating Positive Emotions at Work

Work engagement is defined as a positive, fulfilling, work-related state of mind that is characterized by vigour, dedication, and absorption. Engaged workers are full of energy (vigour), strongly believe in their work (dedication), and are often fully concentrated and happily engrossed in their work activities in a sense of flow in which time passes quickly (absorption). Job resources have been shown to enhance work engagement (Xanthopoulou et al., 2007) [13]. Work engagement in turn has positive effects on organisational outcomes. In a worldwide study involving 7939 business units in 36 companies by the Gallup Organisation, Harter, Schmidt, and Hayes (2002) [35] reported that employee satisfaction and employee engagement has a considerable effect on business outcomes.

Changes in management practices that enhance employee engagement will bring about positive business outcomes including profits.

Humans have a natural affinity for nature and biophilic design of workspaces helps enhance all three components of work engagement by bringing humans closer to nature (increase in vigour, dedication, and improved flow at work). Connection to nature in workspaces can be seen as bringing about an increase in internal personal resources. This give rise to positive emotions, which can bring about work engagement and positive effects on organisational outcomes.

The next section presents system dynamics models of occupational stress.

4. System Dynamics Models on Occupational Stress

System dynamics methodology enable understanding and describing counter-intuitive behaviour of complex systems. Two system dynamics models that quantify time varying occupational stress related parameters are available in the current literature. They were reviewed with a focus on work place design and connection to nature aspects in this section.

4.1. Morris et al. 2010 Model

Morris et al. (2010) [36] presented the definitions of following terms: Stress, Eustress, Distress, Demand, Resource, three Coping styles (Action-oriented, Emotion-oriented, Avoidant-oriented), three Degrees of stability (Emotional, Biological, Cognitive), Response action, two Locus of control (positive, negative), Cortisol level, Anxiety, and Heart rate as described in Hobfoll (1988) [37]. A simplified causal loop diagram (CLD) presenting the model is shown in Figure 4. The simulation time step used in Simgua's (2018) [38] model was one hour and the analysis period was 12 h. As shown in Figure 4 stress is the outcome resulted from demands, resources and job control. Perceived problem demands and stress are "positively correlated (i.e., when one increases or decreases so does the other)" [36] p. 4371. Perceived resources and stress are "negatively correlated (i.e., when one increases or decreases the other does the opposite)" [36] p. 4371. Job control and stress are also negatively correlated. Stress and health problem indicators (cortisol level, anxiety, and heart rate) are positively correlated. The model is able to simulate the behaviour of stress in a quantifiable manner for the 12 h analysis period. However, no work place design nor connection to nature aspects are considered by the model.

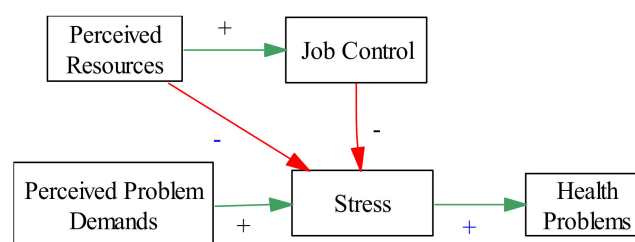


Figure 4. Morris et al. (2010) model [36] presented in a casual loop diagram. Note: green arrows indicate positive causal relations, and red arrows indicate negative causal relations.

4.2. Jetha et al. 2017 Model

A multidimensional system dynamics model (SDM) of workplace stress among nursing aides was developed by Jetha et al. (2017) [39]. By applying the model, they conducted simulations to illustrate how changes in psychosocial perceptions and workplace factors might influence workplace stress over time. Perceived workplace stress, Job demands, Job control, Job resources (Workplace social support) were considered (Figure 5). The analysis period used in their Vensim (Ventana Systems, 2018) [40] model was 10 weeks. Job demands and perceived workplace stress are positively correlated and job control and stress are negatively correlated as in Morris et al.'s (2010) model [36]. However, perceived workplace stress is considered as one of the determinants for job resources (note the backward arrow to job resources in Figure 5) and they are negatively correlated. The model is able to simulate and

quantify the effects of changes in job control, job demands and job resources (workplace social support) on perceived workplace stress. However, no parameters directly related to work place design and connection to nature aspects are mentioned by the model.

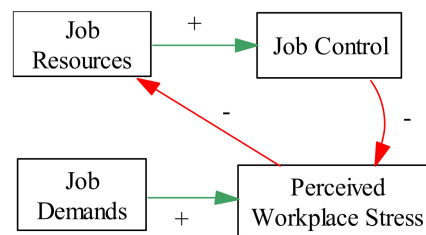


Figure 5. Jetha et al. (2017) model [39] presented in a casual loop diagram. Note: green arrows indicate positive causal relations, and red arrows indicate negative causal relations.

5. Green Buildings, Wellbeing and Connection to Nature

Green building rating tools have been developed to encourage and incentivise pushing the boundaries on sustainability. In this section how these tools address wellbeing and relate connection to nature have been explored. Work stress aspects of biophilic design, which aims to make use of natural elements in architectural and environmental design, is also investigated (Section 5.2). The relationships between connection to nature and wellbeing (Section 5.3), connection to nature and workplace design (Section 5.4) are also explored. In Section 5.5 a model which considers connection to nature as a resource is proposed.

Singh et al. (2010) [41] investigated the effects of improved indoor environmental quality (IEQ) on perceived health and productivity in occupants who moved from conventional to Leadership in Energy and Environmental Design (LEED)-rated green office buildings. They presented the linkages between seven IEQ attributes and productivity/wellbeing attributes. IEQ attributes were: indoor air quality, temperature, humidity, ventilation, lighting, acoustics, and ergonomic design and safety. Two physical wellbeing attributes used by Singh et al. (2010) [41] were asthma and respiratory allergies. Two psychological wellbeing attributes were stress and depression. They reported perceived improvements in stress and depression after the move into the new LEED rated building. Heerwagen (2000) [42] summarised the potential implications of green building design on health and wellbeing. They reported that increased access to daylight and window views are likely to have positive impacts on psychological functioning and wellbeing. Views with natural settings or urban settings with trees are associated with stress reduction and positive emotional states.

5.1. How Current Green Building Rating Tools Address Wellbeing and Connection to Nature

The current green building rating tools: Leadership in Energy and Environmental Design (LEED) [43], Building Research Establishment Environmental Assessment Method (BREEAM) [44], Green Star Design and as Built v 1.2 (GBCA, 2017) [45], GreenMark (BCA, 2016) [46] were investigated by Loh (2016) [47] for how the rating tools included the health and wellbeing of the building occupants. Loh (2016) [47] reported that no direct points are awarded to design decisions made specifically for the health and wellbeing of the building occupants (Table 2). It was found that no direct points are awarded for connection to nature by the current green building rating tools.

Table 2. Green building rating tools and ways of addressing wellbeing (adapted from Loh, 2016 [47]).

Tool	Physical and Psychological Wellbeing
LEED—US Leadership in Energy and Environmental Design	Indirectly affected through air, water and light
BREEAM—UK Building Research Establishment Environmental Assessment Method	Items termed for wellbeing are somewhat similar to IEQ items in other rating tools
Green Star—Australia Green Building Council of Australia (GBCA)	Indirectly affected through IEQ
GreenMark—Singapore Building and Construction Authority (BCA)	Indirectly affected through IEQ

5.2. Biophilic Design

The Biophilic design hypothesis posits that there will be an instinctive relationship between humans and a natural ecosystem, a natural attachment to nature [48]. The concept aims to make use of natural elements in architectural and environmental design. Table 3 shows a summary of some of the elements and patterns used in biophilic design.

The traditional workspace should therefore mimic natural environments in three aspects: (a) nature in space which refers to a direct experience of nature such as light or wind or plants (b) the production of nature mimicking nature where it is possible using natural materials or symbolic representation of nature (c) Characteristics of space in which one can observe nature or provision of a space for refuge. Using this principle, it would be easier to design such biophilic features into buildings and work areas before they are built. Incorporating features such as use of natural light or use of natural construction materials may be difficult in renovation projects.

Table 3. Biophilic design patterns (Adapted from Browning, Ryan & Clancy, 2014 [49] and Lee and Park, 2018 [50]).

Category	Design Patterns
Nature in the space patterns	Visual connection with nature Non-visual connection with nature Non-rhythmic sensory stimuli Thermal and airflow variability Presence of water Dynamic and diffuse Light Connection with natural systems
Natural analogues patterns (Production of nature)	Biomorphic forms and patterns Material connection with nature Complexity and order
Nature of the space patterns (Characteristics of space)	Prospect Refuge Mystery Risk/Peril

Kellert and Calabrese (2015) [51] presented three categories of experience of nature in biophilic design framework. They are: direct experience of nature (natural light, air, water, plants, animals, weather, natural landscapes and ecosystems, fire); indirect experience of nature (images of nature, natural materials, natural colours, simulating natural light and air, naturalistic shapes and forms, evoking nature, information richness, age, change, and the patina of time, natural geometries, biomimicry); and experience of spatial features characteristic of the natural environment (prospect and refuge, organized complexity, integration of parts to wholes, transitional spaces, mobility and wayfinding, cultural and ecological attachment to place). The combinations of various biophilic design features on experience of nature would have varying effects on wellbeing. The current literatures have been largely

prescriptive about the built environment design patterns enabling connection to nature, they did not however quantify these effects on wellbeing.

5.3. Connection to Nature and Wellbeing

Over the past few decades, researchers in psychology have reported on how nature and green spaces have a positive effect on mental wellbeing, physical wellbeing, vitality, personal autonomy and growth [52]. Ulrich (1979) [53] argued that fundamentally people showed an aesthetic preference for natural landscapes over urban ones and that these natural landscapes have positive influences on emotional and physiological states. Ulrich (1983) [54] also postulated that people's affective response to the natural environment can be learned in that there is post cognitive processing and adaptive behaviour after the initial affective encounter. Although the key visual properties (complexity, texture, depth, etc.) of natural environments influence aesthetic preference, environmental perception is multimodal and not limited to the visual senses. While studies among Western groups have shown preference for natural environments there are similarities with the preferences of different cultures for visual natural environments, Ulrich (1983) [54] recognised that culture plays an important role in determining aesthetic preference. Prominent man-made features however will depress aesthetic preference. These past works positively underline the strong relationship between natural environment and both emotional and physiological wellbeing. It therefore follows that a well- designed work environment with strong connection to nature would have positive effects on people using the workspace.

The restorative effects of green spaces and nature is well known. Ulrich (1983) [54] also suggested that there are psychophysiological restoration effects in visual landscapes and that people recuperates from stress more quickly if they are exposed to visual encounters with nature. In a study of recovery data of patients in a hospital, patients who had views of trees showed a shorter post-operative stay than patients who were assigned rooms with wall views. Views of vegetation and water elicit positive feelings and reduced fear which might foster restoration from stress [55]. Therefore, it is suggested that the immediate work environment with strong connectedness to nature would therefore promote wellbeing by promoting restorative processes.

Workplace design such as offices or workspaces are also very much dependent on the overall building design. Salingaros and Madsen (2008) [56] argued that architects in their design, impose artificial meaning on buildings that do not connect human beings to the place they inhabit and offered a theory to explain how well connected buildings create a sense of wellbeing, with positive and therapeutic consequences on physiology. This connection between nature and wellbeing has been applied to the design of built environment, especially in hospital design. There is a strong body of evidence to suggest that proper hospital designs that provide full views of gardens, access to nature, exposure to art and low noise can be very effective in reducing stress and pain for patients [57].

Cleary et al. [58] defined nature to be an environment free of human interference and suggested there is a continuum of different levels of human intervention in an urban environment such as gardens to urban forests, canals and rivers. The connection to nature is the mix of feelings and attitudes that a person has towards nature and suggests that eudaimonic wellbeing is associated with nature connection. This continuum of different levels of human intervention is an important design consideration for architects, designers and managers.

5.4. Connection to Nature and the Workplace Design

In the design of the urban environment to incorporate elements of nature, even something as simple as indoor plants was found to have a positive effect on workers' wellbeing [59]. On a larger scale, in a longitudinal study of workers in a building site office, Gray and Birrell [60] reported that biophilic designed workspaces have a positive effect on wellbeing, fostering a collaborative work environment and job satisfaction. Yet in another study of 64 knowledge workers, the types of workspaces that are considered conducive to promoting wellbeing were investigated and outdoor workspaces were found to be most conducive (Mangone et al.) [61]. Despite evidence of effectiveness in promoting

wellbeing, the use of nature connectedness has not been widely applied to ergonomics or human factors engineering [62] and this calls for a critical review of human factors and ergonomics (HFE) principles to incorporate green principles. Richardson et al. [63] suggested that the three research themes of connectedness to nature, wellbeing and workplace design are closely connected and further research needs to be done to examine and understand how these can be applied. In summary, connection to nature has positive effects on wellbeing and promotes restoration from being stressed. Connection to nature can be incorporated at varying degrees or levels into the local areas such as the immediate workspace as well as integrated into the overall building design.

5.5. Connection to Nature as a Resource

In a worldwide study by the World Health Organization, the Global Burden of Diseases Study [64], cited stress related illness, such as mental health disorders and cardio-vascular disease, to be the two largest contributors to disease. This was enough to call for a worldwide action plan to improve mental health [65]. Schultz (2002) [66] (p. 61) stated “We are borne in nature; our bodies are formed of nature; we live by the rules of nature.”. Schultz (2002) [66] argued that people living in industrialised nations are largely segregated from nature. With a diminished connection to nature, the increasing pressure on urban space and the ubiquitous technological presence we have less opportunity to recuperate our mental and physical energy. One of the quotes by Leo Tolstoy, a Russian writer and philosopher, “One of the first conditions of happiness is that the link between Man and Nature shall not be broken.” [67] (paragraph. 14) clearly highlights the importance of connectedness to nature. Marcus and Sachs (2013) [68] noted that connection to nature is one of the most effective forms of positive distraction in the healthcare setting. “The deeper the connection to nature is, the grater the therapeutic benefits are.” [68].

Based on self-reports of 267 participants in a survey, Tauber (2012) [69] concluded that connection to nature directly affects an individual’s physical wellbeing and psychological wellbeing. Connection to nature may also be considered to be a positive stimuli to promote engagement and pleasure for people with dementia [70]. Many researchers [51,52,58–62,71–74] have argued for the wellbeing benefits of connection to nature. The common reasons include health benefits for employees, improved wellbeing, positive feelings of happiness, creativity and productivity. Some have also argued that humans have an innate attraction to nature. Others have argued it provides for sensory richness, natural rhythms, challenges in nature and local distinctiveness. Yet others have argued that channellings the outdoors into our own workspace is within our psyche and that it is natural for humans to work in natural environment research. However, some of these claims are not yet grounded in rigorous research.

Amidst these claims of the health benefits of connection to nature, there is some ongoing academic work to investigate the health effects. The framework of biophilic design presented by Kellert and Calabrese (2015) [51] applies various natural phenomena to the built environment. The Human Spaces report (2016) [75] reported positive interim results of an ongoing study on the use of biophilic designs in workspaces. In a review of the psychological literature on the health and wellbeing benefits of biophilic design, Gillis and Gatersleben (2015) [76] also concluded that the presence of restorative qualities in biophilic design in a built environment can help foster recovery from stress and mental fatigue. The health benefits of helping patients recover is also documented by Totaforti (2018) [77] using the case study of a hospital, where she argued for the use of the healing powers of nature.

Table 4 shows strengths and limitations of the current models and concepts concerning work design, workplace design, stress, wellbeing and connection to nature as put forward over the years. It should be noted that none of these models consider connection to nature in work design. It justified the development of a new improved model which includes connection to nature.

Table 4. Summaries of models and concepts.

Model	Strengths	Limitations
JD-C Karasek [11]	Related work design to occupational stress. Correlated control can alleviate the negative demands of a job.	Simplistic in approach with just two elements. Inconsistent empirical evidence [19,22]. Does not account for any resources.
JD-R Bakker [7]	Correlated job resources to job demand, to explain employee burnout and engagement.	The nature of job demands and resources is not clear or not explained. The role of personal resources is not implicit in the model [26]. Resources are also discussed generally and not in relation to nature.
COR Hobfoll [33]	Described stress as a coping behaviour in which people build or deplete resources.	Does not explain the source of stress or the role of other resources in the workplace.
SDM of stress Morris et al. [36]	Incorporated coping styles and, locus of control and health.	No discussion on workplace design or the role of nature.
SD of workplace stress Jetha et al. [39]	Incorporated workplace stress, job demands, job resources and control as a model using system dynamics approach.	No direct discussion on workplace design or the role of nature.
Nature as a new paradigm Richardson et al. [63]	Integrated the three research themes of connected to nature, workplace design and wellbeing and the role of ergonomics.	The role of stress is not articulated. Not supported by empirical evidence.

Based on the review of the relevant research literature we proposed an improved model. We apply the COR theory [9] and combine it with JD-R model [7] to explain the mechanism by which a job resource of having green natural work environment can reduce stress which in turn in alleviates the negative effect of a high job demand situation (Figure 6). In particular, the combined JD-R model and COR theory is used to show that having connection to nature elements of nature has a positive effect on organizational outcomes. We postulate that personal resources are an important part of the process and that (a) physical resource can directly promote wellbeing. Some may argue that green natural environments are a physical resource; (b) physical resources affect our energies [9] and can be seen as aiding the value of other types of resources. An example of this would be that nature connected spaces maximize our use of relevant personal traits in that it allows concentration and a sense of awareness.

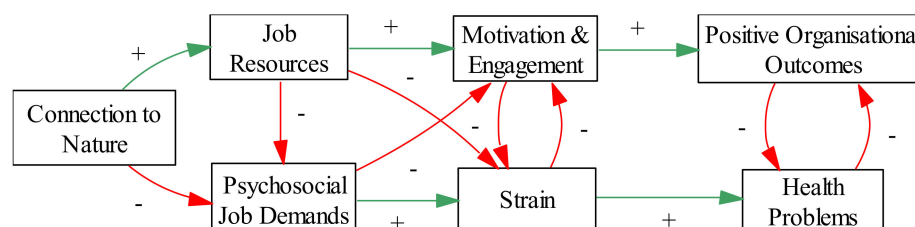


Figure 6. A causal diagram relating connection to natural and wellbeing outcomes. Note: green arrows indicate positive causal relations, and red arrows indicate negative causal relations.

The strength of the model is that it can explain the causal effects of connection to nature as a job resource. The limitation is that it may be challenging to validate the model with objective measures as it requires multi-disciplinary investigations (architectural, building engineering, human factors engineering, psychology, health science and information technology).

The presented model addresses the limitations of the existing models and concepts shown in Table 4. The new conceptual model presented in Figure 6 accounts for job resources, clarifies the role of resources in relation to nature, explains the source of stress (or strain) and its relation to resources, includes a role for connection to nature. It implies that connection to nature must be included as part of good workplace design for wellbeing benefits. The model shows how connection to nature could reduce health problems and promote positive organisational outcomes. The following section is an extensive discussion of the how this model bridges the knowledge gaps.

6. Discussion

6.1. Connection to Nature, Work Design, and Wellbeing

The proposed model incorporates connection to nature as an essential element in workplace design. Previous research has not combined the three elements of connection to nature, workplace design, and wellbeing in a consistent manner [63]. As suggested by Richardson et al. (2017) [63], the consideration of connection to nature introduces a new paradigm in workplace design and wellbeing, two themes that are well developed in the field of ergonomics. Cleary et al. [58] argued that nature exists in the urban environment as urban nature in varying degrees and spans a continuum that correlates to different levels of human influence. This varying of human influence can be categorised by the level of human interference. At low levels, it can be a picture of nature or a potted plant in an office. This can progress to a higher level of connection to nature such as use of furniture made of natural materials or mimicking natural surroundings. At the highest level, this would mean even less artificial nature such as locating the workplace in a garden. The model also suggests that the degree of connection to nature can be measured and used as an element in workplace design. There is an ever-increasing body of research and empirical evidence that connection to nature has positive effects on mental health and wellbeing [52]. The design of a workplace conducive to aiding high performing individuals and teams would be an invaluable resource. While researchers in the field of ergonomics investigated many technical aspects of workplace design such as layout, use of technology, or safety, the consideration of connection to nature would enhance the use of personal resources (psychological and physical wellbeing). Thus, there is a need to integrate the field of ergonomics, building, and workplace design with the concept of connection to nature to support more positive organizational environments.

6.2. Managerial Implications of Connection to Nature Enabling Workspaces

There are two key managerial implications for incorporating connection to nature into workspaces: physical wellbeing and psychological wellbeing of workspace users. In catering for the physical wellbeing, managers and designers ensure that the people using the workspace are safe and not exposed to any form of hazards. The second aspect is important in that psychological wellbeing such as the engagement and positive emotions of workspace users can be enhanced by good workspace design.

6.3. The Cost of Unhealthy Workplaces

Buildings that are poorly designed may lead to occupants displaying symptoms of sick building syndrome, a medical condition where occupants may display a number of symptoms such as general irritation of skin, or general health problems, headaches, and hypersensitivity. A New South Wales Standing Committee on Public Works Report (2001) outlined the widespread problem in Australia and pointed to generally accepted causes of this syndrome that are related to the way buildings are designed, fitted out, or operated. This includes (1) poor building design, particularly when the occupants are totally isolated from the outside environment; (2) use of artificial lighting and 'air'; (3) indoor air pollutants such as chemical, biological, and physical originating from building and fit-out materials and heating ventilation and air conditioning (HVAC) systems; (4) poor design and operation of HVAC systems; and (5) psychosocial factors such as management attitudes in the workplace, stress, and interpersonal relationship. The report recommended the use of sustainable design principles, environmental design considerations, natural ventilation, limiting sources on pollutants, and improved indoor air quality as steps towards minimizing sick building syndrome. These measures are totally in line with the principles of biophilic design of workspaces [49].

6.4. Occupant Safety and Wellbeing

Apart from the sick building syndrome, badly designed workspaces also pose risks to occupants in the form of ergonomic issues and exposure to noise. Ergonomics is the study of human interaction with other elements of a system. Attaianes (2012) [78] applied the same principles to building design

and suggested that high performing buildings should take into consideration the elements of (1) energy efficiency with a low carbon footprint, (2) functionality for its planned use by its occupants, (3) ease of operation and maintenance, and (4) protecting occupant comfort. Through its designed characteristics, the building should contribute to sustainable development and at the same time, decrease use of resources; decrease environmental impact; and increase of health, safety, and comfort of the occupants. Protecting occupants from noisy environment and the use of appropriate lighting levels are examples of occupant comfort. These considerations are also in line with the biophilic design principles [49].

6.5. Psychological Wellbeing (Promoting Human Capital Development)

Apart from the physical aspects of wellbeing, connection to nature is also known to give rise to positive emotions. These positive emotions are resources that can be used to create more resources, which in turn is good for the organisation. Human capital is considered one of the most important factors of production. In the 18th century, Adam Smith defined it as the useful benefits from the members of a society. It comprises knowledge, skills, competences, habits, and personalities needed to perform labour. The nature of tasks assigned to working people has changed over the years, from the menial labour during the Industrial Revolution to highly skilled occupations in the 20th century. With the rapid advancement of technology where computers equipped with artificial intelligence can replace human beings in more and more tasks, the work performed by people in the 21st century will change rapidly, and will require higher amounts of creative and innovative outputs from people [79]. Innovation is a nebulous concept, which may mean different things to different people. However, at the root of it, organisations need their people to be creative in doing things differently from others to stay ahead of the competition.

New skills such as the ability to work well in teams will be emphasised. The measure of people's emotional intelligence, the emotional quotient, will be as important as the traditional measure of intelligence, the intelligence quotient (IQ) [80]. In the aim to raise productivity and profitability, organisations will have to be on top of their game and ensure that their working units have high performing teams.

While it is recognised that providing right skills, training, and opportunities is an important step, organisations must also create the comfortable indoor environment and work climate for this to happen. Good workspace design is seen as a facilitator of this aspect of organisational productivity. It enhances people abilities to stay healthy [81] and enhances collaboration and teamwork [82,83]. It also enhances people's abilities to be innovative through better work engagement [18]. The underlying principle behind Biophilia is that people want and need to be close to nature [48]. Connecting the work to nature would be an enabling factor in work productivity.

7. Conclusions

Provision of connection to nature in workspaces would contribute to a holistic and comprehensive approach in the design and build of workplaces and work environments as it enhances physical and psychological wellbeing, as well as positive emotions at work. A new model that incorporates connection to nature into workplace design for wellbeing has been proposed. There are two types of employee wellbeing: a physical or physiological wellbeing, and mental or psychological wellbeing. The connection to nature in workplaces is a job resource that has this dual effect on wellbeing. The model we have presented combines the three broad research themes of connection to nature, workplace design, and wellbeing, as suggested by Richardson et al. (2017) [63].

The innovative aspects of the model are as follows:

- It includes nature as a resource or a pre-requisite in workplace design.
- It explains the mechanism of how these themes (connection to nature, workplace design, wellbeing) are connected. It is through connection to nature as a job resource that stress is reduced (wellbeing improves). It should be noted that previous research has either focused on

connection to nature and workplace design or connection to nature and wellbeing, or workplace design and wellbeing, but not all three combined. Only Richardson et al. (2017) [63] showed that the three broad research themes of workplace design, wellbeing, and connection to nature can be combined in a new ergonomic paradigm.

We propose connection to nature in workplace design as a spectrum. We attempt to organise various connection to nature themes into a spectrum of categories. This spectrum illustrates various levels of connection to nature ranging from low levels, for instance, having a photograph of a plant, to mid levels, for example, the use of natural materials like wood and stone, and up to high levels such as locating an office in a forest or a zoo.

8. Future Research

1. We recognise that temporal and spatial aspects (e.g., frequency and duration) of connection to nature has varying effects on people. This needs to be explored further.
2. There is a need to refine the subjective measures of wellbeing and measures of workplace design that relate with connection to nature. Earlier research applied subjective self-reported responses to surveys, however, with the current advances of the sensor technology and the Internet of Things (IoT), wellbeing can be objectively measured.
3. Guidelines on the inclusion of connection to nature in workplace and building design considering human factors need to be developed.

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