Promoting students’ well-being indicators through adapting biophilic design attributes in Salahaddin University dormitories

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ARTICLE INFO

Article history:
Received 22 February 2023
Received in revised form 05 April 2023
Accepted 20 My 2023

Keywords:
Biophilic design attributes
Well-being
University dormitories
Virtual reality
Stress
Physical indicators

ABSTRACT

Due to its positive impact on human psychophysiological indicators, biophilic design can be implemented in various built environments. This design approach can be used when the connection to natural elements is limited and when the occupants feel stressed and uncomfortable in a specific space. Purpose: This research aims to investigate promoting Students’ well-being indicators through adapting biophilic design attributes in Salahaddin university dormitories. Subjects: A cross-sectional field experiment conducted with 39 University students. Design: The participants experienced one of the two simulated rooms by using a virtual reality headset (VR). The first was a biophilic design room BDR based on the adopted BDAs, and the second was a non-biophilic design room NBDR. Besides, all participants performed a stress induction task SIT. Measures: Participants’ physiological indicators were measured twice, one before and the other after the experiment. Measures included heart rate HR, Systolic blood pressure SBP and diastolic blood pressure DBP. Result: Paired-Samples T-Test was used to compare the mean of physiological indicators. The P-values of physiological indicators were statistically significant (P<0.05). Conclusion: This study provided statistical evidence that BDAs can provide a restorative environment that positively affects human psychophysiology indicators, and NBDR provide a more stressful environment. VR is a powerful research tool if an empirical experiment and time/cost limit is now allowed.

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1. Introduction

Students at universities frequently experience study-related stress as a result of high expectations from themselves and others, exam and class pressures, and a lack of time, skills, money, and sleep [1]. “These and related stressors can have a negative impact on student’s health, well-being, and academic achievement” [2], [3]. If students experience such negative feelings during their lectures, they may persist during the day and influence their overall well-being [4]. In addition, according to the study [5] study-related stressors can negatively impact student academic achievement. These negative impacts on students’ well-being can be eliminated by facilitating Indoors, where the students spend time in there. Indoor nature in classrooms can positively reduce these related stresses and improve students’ psychophysiological aspects [4]. The physical environment of educational building classrooms is a supportive environment that boosts students’ performance [6], [7]. According to the studies [4], [8], [9], the
presence of natural elements in the indoor environment of educational buildings is positively related to the student’s attention and efficiency. “Indoor nature can provide a range of positive physical and psychological health benefits” [10].

In addition, other strategies can be adopted to maximise well-being and physical indicators. Exposure to daylight significantly impacts users’ physical and mental health [11]. The existence of water in a built environment gives a sense of calm, relaxation, and comfort [12], [13]. Using natural materials can reduce stress [13], have health benefits [14], and can help recover from stress and anxiety [15]. Using natural colours impacts students’ emotions, including feelings of happiness and excitement [16]. According to [13], spatial features and characteristics of a space that have advanced human health and wellbeing. All the mentioned strategies falls into attributes of BD This study focus on facilitating and adopting BDAs to promote and enhance student physical indicators and well-being.

1.1. Theory and application of biophilia

Biophilia as a theory was started when first mentioned by social-psychoanalyst Erich Fromm in 1964. Then the term biophilia became more popular when the Socio- biologist Edward O. Wilson described it in his work biophilia (1984). but Biophilia theory did not receive broad perception and recognition even after two decades after it was first proposed. According to [17], the theory of biophilia is still in its initial development phase.

Biophilic design is the application of this theory. The first attempt to empirically apply this theory in a physical environment was by [18], Stephen Kellett identified various mechanisms for creating a biophilic experience in buildings, [19] defined Biophilic design as an “extension of biophilia”, and they stated it is an innovative way of design that tends to enhance human beings’ connection with nature in workplaces to induce well-being effects.

The term “biophilia” comes from the Greek language and consists of two elements “Bio” and “Phile.” The word “bio” denotes “life,” and the suffix “phile” indicates “Who” loves. The notion of biophilia was initially presented by Erich Fromm, an American social psychotherapist, in his book The Heart of Man (1964) and described as “the passionate love of life and of all that is alive” [20]. When sociobiologist Edward O. Wilson published his book Biophilia (1984), the word “biophilia” became increasingly prominent, and he described biophilia as “the innate tendency to focus on life and lifelike processes” [21].

1.2. Impacts and benefits of Biophilic design in the built environments

Biophilic design is not specified to a particular building typology or a specific level of the built environment. Applications of biophilic design range in scale from interior design to building design to parks, streetscapes, and urban design [22].

Biophilic design is more complex than simply incorporating vegetation and greenery into buildings. It broadens the range by including various types of nature, such as physical, sensory, metaphorical, morphological, material, and spiritual (Zhong et al., 2021). As the Biophilic design enhances the incorporation of natural elements into different levels of the built environments, it has various significant impacts on human beings [22].

A successful biophilic-based designed building depends on to what extent the built environment is restorative. According to [11], A high-quality biophilic design significantly reduces stress within built environments and improves the users’ physical health. Moreover, Biophilic design creates environments that are restorative to human psychology, relax the nervous system, and demonstrate the aesthetic of life [23]. Biophilic buildings must improve human well-being and comfort by providing a restorative environment for recovery from stress and mental fatigue. [24].

Biophilic architecture employs a design strategy that focuses on re-establishing the connection between people and nature [13]. Buildings should be designed in such a way that they increase the connection between occupants and nature [25]. The biophilic design creates an environment that improves the connection between humans and nature [26]. Biophilic design aims to positively affect occupants by connecting and linking them to nature [27].

1.3. University students and dormitory buildings

University Students often experience study-related stressors because of high achievement expectations, exams, study fees, economic conditions, and lack of time [1]. These study-related stressors can have a negative impact on students’ academic achievement [2], [5]. Exposure to stressors can negatively impact individuals’ health (Jex & Beehr, 1991) as cited in [1]. Direct contact with nature in classrooms can significantly promote attention and reduce related stresses [4]. During their classroom stay, university students must focus, absorb information, and pay more attention [4].

Among university students, special consideration should be taken to the students in dormitory buildings; besides other study-related stressors, leaving family is another stress on them. Family stressors were mentioned for several reasons, including leaving family behind to go to school [1]. In addition, most of the studies were conducted in the university buildings, neglecting the built environment in which the students spent roughly two-thirds of their time during the study season. The current study will be conducted in that specific area (The students’ room).

1.4. Attributes and variables of Biophilic design.

Patterns and attributes are the terms and names that the researchers have used to determine the variable of this design approach. The most well-known studies are the study by [13], [18], [28]. The researcher [18] recognised six biophilic design elements and roughly 70 attributes. The study of [28] Identified three main categories, which are: “nature in the space”, “Natural analogue”, and “nature of the space”. Furthermore, After seven years, [13] refined 70 design attributes and condensed them into twenty-four design attributes.

2. Literature review

Due to its significant impact on various psychophysiological indicators, many researchers investigated BD’s impact. The effects vary and depend on the type of population and building. According to the studies of [30], [31], [32], [33], BD positively impacts office workers. The researchers conducted their research in office buildings, they involved building officers in their study and adopted various BDAs. Research designs were simulated experiments, on-site experiments and both together. The impacts were identified by measuring and monitoring the psychophysiological indicators of the participants. Their research showed that BDAs significantly promote physical well-being and
effectively improve workplace health, well-being, productivity, work efficiency and stress levels.

Nonetheless, the study of [11] investigated the impact of daylight on the healing environment in hospital rooms. The research was conducted in a hospital building, and the researchers adopted a questionnaire to get patients’ self-reports. The researchers demonstrated a significant relationship between natural daylight and the healing process of the patients. The research results clarify that BDAs are a powerful tool to enhance and promote psychological and physiological indicators of building occupants.

3. Current study variables

3.1. Biophilia variables adopted for the current study

To investigate the impacts of BDAs on students’ well-being, this study adopted BDAs based on two criteria as per below:

The first criterion was to involve the least studied BADs. Variables were air, animal, fire, naturalistic shapes & forms, biomimicry, and prospect based on the reviewed studies which involved students. The second criterion was to focus on those BADs that influence physical well-being. Variables were light, plants, water, natural landscape, natural material, the image of nature, natural colours, and simulating natural light & air based on the studies of [13], [28].

3.2. Current study’s simulated design

The current study adopted a between-subjects design; a between-subjects design creates two conditions in which the participants are randomly assigned and experience only one of the two conditions. Many researchers use this study type (Yin et al., 2019; Roskams & Haynes, 2020; Valtchanov et al., 2010; McSweeney et al., 2021). The reason is to compare and find out the differences between participants of the two conditions. Another reason is that a between-subject design is time-effective because the participants experience only one condition, which minimises the duration of the experiment.

3.2.1. Simulated biophilic design

The In this condition, the design of the students’ room achieved all the biophilic design attributes adopted by the current study as mentioned, which are 1) direct experience of nature which includes Light, Air, Water, Plants, Animals, Natural landscapes and Fire; 2) indirect experience of nature which includes Images of nature, Natural materials, Natural colours, Simulating natural light and air, Naturalistic shapes and forms, Biomimicry; and 3) experience of space and place which includes prospect and refuge. The design strategies to achieve the adopted biophilic design are clarifies in Table 2.

3.2.2. Simulated non-biophilic design

In contrast to the first condition, the design of the student’s rooms in this condition does not achieve any of the biophilic design attributes adopted by the current. This condition doesn’t involve treatment or experience [31], [34], [36]. In this environment, the students will experience a simulated environment with a lack of natural exposure, small window, lack of outdoor view, artificial ceiling light, and artificial floor and wall material.

Moreover, other studies aimed to examine the impact of BD on students’ stress, emotion, attention, health, and well-being. Longitudinal and cross-sectional experiments (empirical and simulated) were conducted in educational buildings at different levels (University, Secondary school, and secondary vocational school). The participants were college students, secondary students, and Vocational students. Students’ well-being was measured using bio-sensor and medical tools; psychological indicators were measured through adapting questionnaire. The researchers demonstrated many positive impacts of BD. The nature-based indoor environment might enhance stress recovery [34]. Indoor elements of visual biophilic design significantly impacted student emotions [16]. Biophilic design elements can enhance recovery from stress and reduce anxiety [15]. Classrooms with plants significantly impact students’ performance [9]. Natural sound enhances and facilitates recovery from stress after a stressor task [35].

Table 1. Attributes and patterns of Biophilic design [29].

<table>
<thead>
<tr>
<th>Direct Experience of Nature</th>
<th>Indirect Experience of Nature</th>
<th>Experience of Space and Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>Air</td>
<td>Prospect and refuge</td>
</tr>
<tr>
<td>Water</td>
<td>Water</td>
<td>Organised complexity</td>
</tr>
<tr>
<td>Plants</td>
<td>Plants</td>
<td>Integration of parts-to wholes</td>
</tr>
<tr>
<td>Animals</td>
<td>Animals</td>
<td>Transitional spaces</td>
</tr>
<tr>
<td>Weather</td>
<td>Weather</td>
<td>Mobility and wayfinding</td>
</tr>
<tr>
<td>Natural landscapes</td>
<td>Natural landscapes</td>
<td>Cultural and ecological</td>
</tr>
<tr>
<td>- and ecosystems</td>
<td>- and ecosystems</td>
<td>- attachment to place</td>
</tr>
<tr>
<td>Fire</td>
<td>Fire</td>
<td></td>
</tr>
</tbody>
</table>

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Table 1. Attributes and patterns of Biophilic design [29].

<table>
<thead>
<tr>
<th>Patterns of Biophilic Design, Source: [28], [29]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature in the space</td>
</tr>
<tr>
<td>Natural analogues</td>
</tr>
<tr>
<td>Visual connection -</td>
</tr>
<tr>
<td>-with nature</td>
</tr>
<tr>
<td>-non-visual connection-</td>
</tr>
<tr>
<td>-non-Rhythmic</td>
</tr>
<tr>
<td>-Sensory Stimuli</td>
</tr>
<tr>
<td>Thermal &amp;Airflow</td>
</tr>
<tr>
<td>-variability</td>
</tr>
<tr>
<td>Presence of Water</td>
</tr>
<tr>
<td>Dynamic &amp; Diffuse</td>
</tr>
<tr>
<td>Light</td>
</tr>
<tr>
<td>Connection with -</td>
</tr>
<tr>
<td>- Natural Systems</td>
</tr>
<tr>
<td>Biomorphic Forms &amp; Patterns</td>
</tr>
<tr>
<td>material Connection with nature</td>
</tr>
<tr>
<td>Complexity &amp; Order</td>
</tr>
<tr>
<td>Prospect</td>
</tr>
<tr>
<td>Refuge</td>
</tr>
<tr>
<td>mystery</td>
</tr>
<tr>
<td>Risk/Peril</td>
</tr>
</tbody>
</table>

| Nature of the space                         |
|posium                                    |
The current study adopted the simulated environment in this investigation since it has the same influence as the real environment, and this was proved by the researchers who conducted research in real and simulated environments [47], [48].

The current study utilized a virtual reality device (VR) to perform the simulated experiment. VR is essential for studying and understanding restorative effects [47]. Natural elements in a virtual condition can reduce stress [49]. VR allows users to relax [50] and enhances the emotional well-being of those disconnected from the outdoors [51]. Among the modes of Simulation, the current study adopted the Oculus quest2 VR headset, which gives an immersive 360-degree high-resolution view that makes a more enjoyable experience [22]. In addition, the current study will be the first research that adopts a stress induction task (SIT) locally. The aim is to raise stress levels, HR, and BP over what is considered normal [15], [35], [46], [50], [52].

5. Case studies and participants

The experiment was held in university dormitories in Erbil-Iraq. The case studies to be designed as a dormitory building, should be government property and belong to salahaddin university. Based on that, two dormitory buildings were selected for the current study as below:

- **Shahid Shawkat Sheikh Yazdin (SSSY):** This dormitory is located on the main road of the new Erbil-Kirkuk, in the south part of Erbil-Iraq city. The occupants are 1907 male students. SSSY consists of three buildings, and each is five floors. The total number of rooms is 870.
- **18th Shobat girls dormitory (18th SGD):** It is Located on Zank street in Erbil-Iraq. The occupants are 1100 female students. 18th SGD consists of three buildings, and each is three floors. The total number of rooms is 267 rooms.

As part of academic research, the statistician suggested that up to 40 participants are statistically appropriate for this study.

5.1. Data collection (Measurement tool)

The current study measured physical well-being by using bio-monitoring sensors to record the changes in two physiological indicators as below:

5.1.1. HR measure

Measuring HR is one of the most adopted ways to record physiological changes [15], [34], [35], [39], [45], [49]. HR record is preferable due to easy handling, saving time and cost effect. Heart rate is measured by counting beats per minute (BPM) [45]. The average number of HR is between 60 and 100 bpm, as stated by the American Heart Association (AHA) [53], [54].

5.1.2. BP measure

The SBP and DBP are used to monitor blood pressure (SBP and DBP). According to the AHA and American College of Cardiology (ACC). The typical blood pressure range is between 120 millimetres of mercury (mm Hg) systolic and 80 mm Hg diastolic [55].

The current study measured HR and BP by using a digital wrist Bio-monitoring sensor. The reason for using this medical device is it automatically measures the mentioned physiological indicator an easy to handle.
5.2. Data collection Procedure

The process of experimentation was divided into seven sequential phases:
1. **Preparation:** The overall procedure was explained to the participant, and took information about the VR, Bio-monitoring sensors, and questionnaire.
2. **Survey:** This phase is dedicated to collecting the socio-demographic information of the participants.
3. **Stress induction task:** In this phase, the participants experienced a stressor task; this increased stress levels beyond normal conditions, increased heart rate.
4. **Baseline:** in this phase, psychophysiological data were collected from the participants through a bio-monitoring sensor and questionnaire.
5. **Simulated experience:** In this stage, the participants were randomly assigned to one of the two conditions.
6. **Recovery:** in this phase, psychophysiological data is re-collected from the participants after they experience one of the two conditions.

6. Result

The current study measures physiological indicators to investigate the impact of biophilic design on students’ well-being. Both groups experienced one of the two simulated designs that randomly has been assigned to them. Physiological indicators have been measured twice (before and after the experiment). The current study adopted a One-Sample T-Test to identify whether the impact is significant or not.

### 6.1. Impact of BDAs on students’ HR.

The mean HR of the participants of CG was 92.4 b/min before the experiment, and it increased to 97.25 b/min. While the mean HR of the participants of TG was 82.73 b/min before the experiment, and it decreased to 79.52 b/min.

The result of paired samples test indicates that the impact of BDR on students’ HR is significant (P < 0.05), and it is a significant negative impact. In contrast, the effect of NBDR on students’ HR is significant (P < 0.05), and it is a significant negative impact.

### Table 3. Paired-samples statistics of heart rate HR for both groups before and after the experiment [29].

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG</td>
<td>Mean</td>
<td>Std.Deviation</td>
</tr>
<tr>
<td></td>
<td>92.400</td>
<td>9.150</td>
</tr>
<tr>
<td>TG</td>
<td>82.736</td>
<td>6.401</td>
</tr>
</tbody>
</table>

### 6.2. Impact of BDAs on students’ SBP.

The measure of students’ SBP has been changed after the experiment. The measure of CG’s SBP was 115.45 mmHg before the experiment and became 120.7 mmHg after the experiment. The TG’s SBP was 119 mmHg before the experiment and became 113.57 mmHg after the experiment.

The SBP measure of CG recorded an increase, while the measure recorded less in the TG. Less pressure means less blood pressure on the artery wall, feeling relaxed and nervous.

The result of paired test demonstrates that the impact of BDR on students’ SBP is significant (P < 0.05), and it is a significant positive impact. In contrast, the effect of NBDR on students’ SBP is significant (P < 0.05), and it is a significant negative impact.

### Table 4. Paired-samples statistics of systolic blood pressure SBP for both groups before and after the experiment [29].

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG</td>
<td>Mean</td>
<td>Std.Deviation</td>
</tr>
<tr>
<td></td>
<td>115.450</td>
<td>12.881</td>
</tr>
<tr>
<td>TG</td>
<td>119.000</td>
<td>13.148</td>
</tr>
</tbody>
</table>

### Table 5. Paired-samples statistics of diastolic blood pressure DBP for both groups before and after the experiment [29].

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG</td>
<td>Mean</td>
<td>Std.Deviation</td>
</tr>
<tr>
<td></td>
<td>77.100</td>
<td>10.637</td>
</tr>
<tr>
<td>TG</td>
<td>75.315</td>
<td>9.080</td>
</tr>
</tbody>
</table>
7. Conclusion

This study investigated the application of biophilic design and aimed to identify the way that it impacts university students’ well-being. Biophilic design as a design approach enhance and promote the connection between human and nature. The design can be used when the connection to natural elements is limited or when the occupants feel stressed and feel discomfort in a specific space. BD has several patterns and attributes, and each one has a particular impact on the occupants of a built environment. These patterns and attributes can be adopted in different ways and techniques. This design is restorative rather than aesthetic value. Therefore, this design approach is ideal when there is a lack of connection with the natural environment, less exposure to natural elements, and occupants feel depressed and discomfort.

In this between-subject experiment, two simulated designs were experienced by 39 students of Erbil university dormitories. The first was a BDR, and the second was NBDR. Participants were randomly divided into two groups (TG and CG), and they were assigned to one of the two simulated designs. Their physiological indicators (HR, SBP, and DBP) were measured twice, once before the experiment and the second after the experiment. An automatic Bio-metric sensor is used to record the changes in physiological indicators. The physiological indicators of the participants of TG showed a significant decrease. In contrast, the indicators’ measure became more with participants of TG. The result of statistical analysis (paired Sample T-Test) demonstrates a significantly strong correlation between biophilic design attributes and students’ well-being. The physiological indicators of TG Participants decreased, which indicates that the impact is positive. In contrast, the impact was negative because it increased the physiological indicators of CG Participants.

In conclusion, BD is a design approach that significantly impacts students’ physiological indicators and can be adapted to have a restorative environment.

Authors’ contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

Funding source

This study didn’t receive any specific funds.

Acknowledgements

We want to thank all participants for their time and the administration staff of both dormitories for their help and support.

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