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A STUDY ON THE IMPACT OF GREENERY IN BUILDING INTERIORS ON THE PSYCHOLOGICAL WELL-BEING OF OCCUPANTS

An experimental study with special reference to Personalized Residential Spaces of University Students in Sri Lanka

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Abstract: This study aimed to investigate the impact of indoor greenery on occupants' well-being and design preferences. Previous research on outdoor greenery has left a gap in understanding the relationship between interior greenery and well-being. Using a sample of 36 final year Architecture students, the study tested four interior conditions in varying green coverage ratios and varying observing distances through a 3D simulated setup and virtual methods. The results showed that a high ratio of indoor greenery, regardless of observing distance, was consistently more beneficial than low greenery conditions. Specifically, a high amount of greenery at a far distance delivered the highest levels of psychological well-being, with 61.11% of participants reporting high well-being. In contrast, low greenery at a far distance was the least beneficial combination, resulting in lower well-being (38.89% - low, 2.78% - very low), personal satisfaction, negative feelings, and weaker connection to the indoor space. Most participants preferred indoor courtyards with 50% exposure to natural light due to the sense of naturalness and vibrant shadows they provided. The study recommends that Architects, Interior Designers, and Landscape Architects consider incorporating high indoor greenery at a distance and partial exposure to natural light to promote psychological well-being in future indoor green spaces.

Keywords: *Indoor greenery, Green space design, Psychological well-being, User perception, Undergraduates*

1. Introduction

People spend most of their time indoors in today's urbanized world (Dreyer et al., 2018; Han, 2019), leading to a growing concern about the impact on psychological well-being. The prevalence of physical and mental health issues and declining psychological well-being in contemporary society, may be influenced by the artificial nature of built environments. In contrast, exposure to nature has been associated with numerous benefits for physical and mental health (Han, 2011). Greenery, as a prominent component and symbol of nature, is preferred in living environments to enhance the quality of life (Bringslimark et al., 2009). Architects and designers incorporate green spaces within manmade structures to represent nature. Research has shown that greenery reduces stress, promotes relaxation, and improves mental health and well-being (Haluza et al., 2014). However, the effects of indoor greenery on psychological well-being and perceived naturalness remains unclear. Further exploration is needed to understand the intentional and beneficial integration of indoor greenery in artificial environments. This study aims to investigate the psychological well-being of occupants in relation to indoor greenery and green space design parameters, providing valuable insights into this novel area of research.

1.2. RESEARCH PROBLEM

Most of the available literature evaluating the effect of interior environments on user well-being has only focused on the impact of views, lighting, noise, air quality, and visibility of outside greenery (Akbari et al., 2021). From an Architectural and Design perspective, how the integration of greenery with interiors can be beneficial in terms of user well-being and how the design parameters and design aspects of indoor green spaces affect the psychological well-being of occupants is not established. This study aims to fill in this gap with special reference to personalized residential spaces of university students.

1.3. JUSTIFICATION OF THE STUDY

Existing studies reveal a lack of evidence on the effects of greenery in indoor environments on individuals' well-being (van den Bogerd et al., 2020; Houlden et al., 2018). The COVID-19 pandemic has made shifts in the work and study patterns making remote working and distant learning more frequent. This requires the contemporary society to spend more time indoors compared to pre covid. And the risk of another pandemic cannot be ruled out and it is of

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paramount importance that Architects and Designers embark upon the need to address psychological well-being in indoor environments by integrating greenery with interiors.

1.4. OBJECTIVES

This study attempts in contributing to the understanding of the actual and potential roles natural greenery plays in indoor environments on the psychological well-being of occupants with following specific objectives.

1. Assess the effects of integrating different amounts of indoor green within personalized space, on the psychological well-being of occupants.
2. Assess effects of the positioning of greenery within personalized space (distance between the subject and the green space), on the psychological well-being of occupants.
3. Identify the preferences of occupants regarding the type of greenery integrated with personalized spaces and exposure to natural light.
4. Derive a set of design considerations regarding indoor green spaces from Architectural point of view, focusing on the perspective of user's well-being.

1.5. SCOPE AND LIMITATIONS

Due to the COVID-19 global pandemic and related restrictions, local university students were engaging in online learning from their homes during the period of research implementation. The study selected a sample of final year Architecture students from the University of Moratuwa to minimize variations in factors such as academic stream, workload, activities, age differences, and thinking patterns, which could affect subjective well-being. Simulated 3D videos of experimental setups had to be experienced online via subject's personal monitor/TV as using even Virtual Reality (VR) was not possible as everybody did not have personal access to such facility as well as they could not be provided with such as there were local & global travel restrictions. Therefore, the research and the experiments were carried out online with the best possible resources, materials and methods which were available at the period of a pandemic.

2. Literature Review

Nature plays a vital role in maintaining psychological and physical well-being, as evident from previous research indicating the positive effects of nature exposure on human health and well-being (Van den Bogerd et al., 2020). However, the rapidly urbanizing world has engrossed people in their busy lives, neglecting their physical and mental health problems which is predicted to cost trillions by 2030 (Gascon et al., 2015), influenced by urban environments that are devoid of features supporting well-being. The Covid-19 pandemic has highlighted the importance of green spaces, as people found solace in parks and gardens during lockdowns. Biophilia, coined by biologist Edward O. Wilson, describes humans' inherent attraction to nature and the importance of incorporating nature into our built environments for improved health and well-being (Heath, 2020). Biophilic design patterns, identified through empirical studies, offer various benefits such as stress reduction, enhanced creativity, improved well-being, and accelerated healing, higlighting the importance of incorporating nature into the built environment (Browning & Ryan, 2014).

2.1. INTEGRATION OF GREENERY INTO INDOOR BUILT ENVIRONMENT

Research has consistently shown that incorporating greenery and natural vegetation into built environments has numerous benefits for human psychological well-being (Hartig & Mang, 2016; Berman et al., 2012) as it can promote mental health, reduce stress and anxiety, and enhance overall well-being (Poskitt, 2020; Haluza et al., 2014). Integrating greenery into indoors is much important, as people spend a significant amount of time inside buildings, and such integration allows for nature-based characteristics that recreate the outdoor experience, positively impacting psychological well-being and providing opportunities for human-nature connections (McSweeney, 2016).

2.2. INDOOR GREENERY DESIGN VARIABLES AND PARAMETERS

Research indicates that the distance between occupants and greenery, the amount of green cover in interior spaces, and the specific physical characteristics of indoor plants can significantly impact the physical and psychological environments of indoor spaces. From the perspective of Architects and designers, there are certain architectural design parameters that should be paid attention to when designing and integrating green spaces with interior environments.

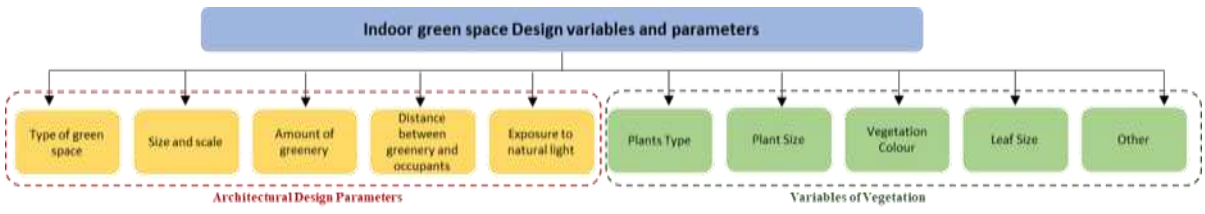


Figure 1, Indoor green space variables and parameters (Source: Author)

2.3. PERSONALIZED INDOOR SPACES IN RESIDENTIAL BUILDINGS AND THE PSYCHOLOGICAL WELL-BEING OF OCCUPANTS

Indoor personalized spaces in residential buildings play a crucial role in occupants' well-being. However, many of these spaces may not adequately support the psychological needs of individuals, which can negatively impact their mental health. Factors like spatial layout, environmental conditions, and Architectural features can significantly influence well-being (Fich et al., 2014). The COVID-19 pandemic has led to a shift in work and learning environments, with many individuals utilizing their personalized spaces for multiple functions, increasing the pressure on these spaces and threatening the psychological well-being of occupants (Akbari et al., 2021). It is important to explore the design of multifunctional personal spaces that can support and enhance mental health and psychological well-being in the current situation and beyond.

2.4. MAIN COMPONENTS AND CONTRIBUTING FACTORS OF PSYCHOLOGICAL WELL-BEING

Well-being encompasses various aspects of psychological functioning and life experience (Deci & Ryan 1985). It is commonly divided into two types: hedonic well-being, which focuses on subjective happiness and life satisfaction, and eudaimonic well-being, which emphasizes purpose and functioning. Hedonic well-being involves positive affect and satisfaction with life (Carruthers & Hood, 2004), while eudaimonic well-being relates to self-determination and flourishing (Watson, 2018). Evaluating factors such as competence, relatedness, autonomy, satisfaction, and positive affect through appropriate well-being models helps measure hedonic and eudaimonic well-being and overall psychological well-being. Preferences also play a role in psychological well-being, as obtaining desired conditions and perceiving their fulfillment contribute to a person's well-being (Griffin, 1986).

2.5. IMPACTS OF INDOOR GREENERY IN RESIDENTIAL ENVIRONMENTS ON THE PSYCHOLOGICAL WELL-BEING OF THE SAMPLE SELECTED (UNDERGRADUATES) FOR THE STUDY.

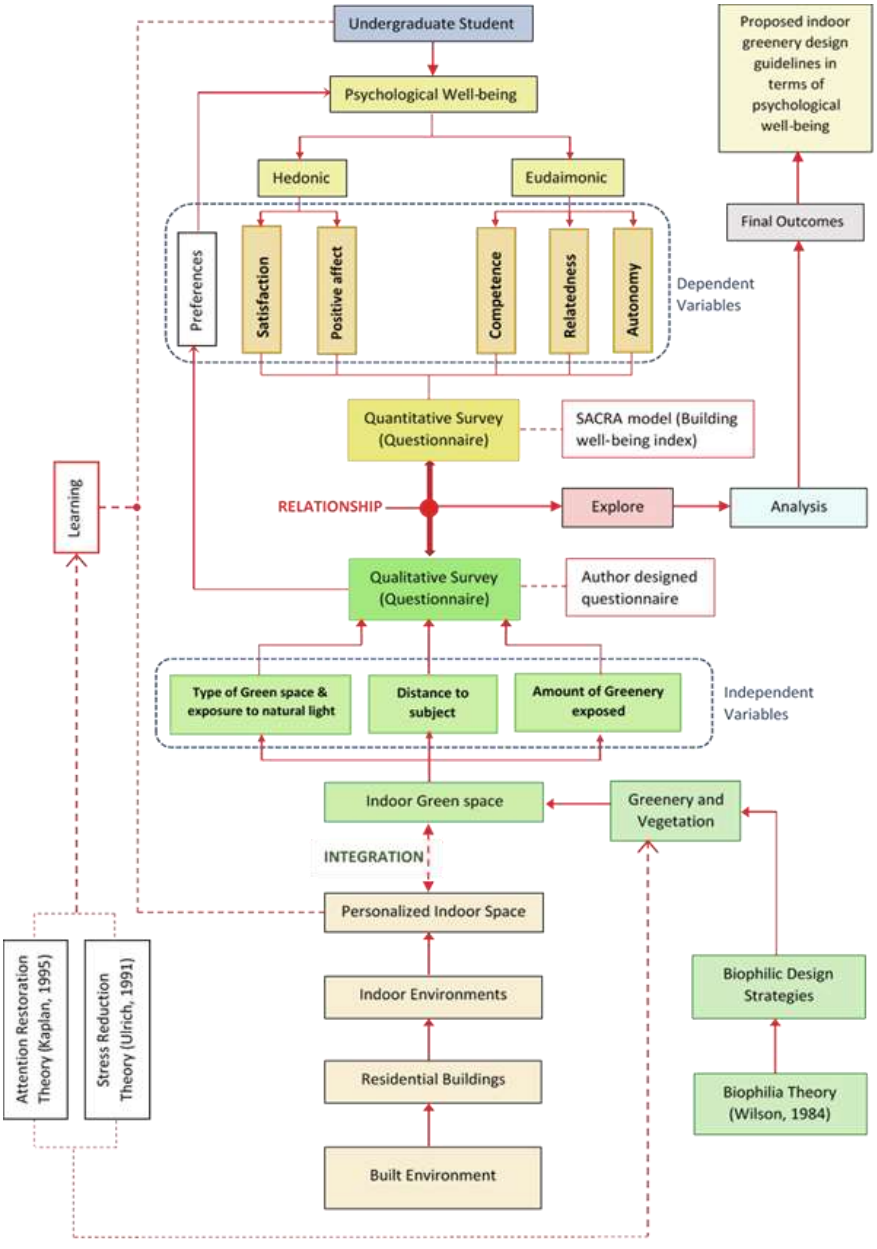


Figure 2, Research Framework (Source: Author)

The psychological well-being of students is crucial as it directly affects their academic performance and prospects. Numerous studies have demonstrated the impact of mental health on academic success, showing that students with positive mental health achieve higher grades (Roeser et al., 1999). Depression has been linked to poor academic performance and higher dropout rates among students (Eisenberg et al., 2009). Positive moods have been associated with flexible thinking, creativity, and improved cognitive performance, while negative moods can hinder performance (Greene & Noice, 1988; Rüppel et al., 2015). University students face unique challenges and are more susceptible to depression, anxiety, and stress due to the transition to adulthood and the demands of academic life (Eisenberg et al., 2007; Park et al., 2020).

In the current context of remote learning during the COVID-19 pandemic, students rely on their indoor residential spaces for studying. Incorporating indoor greenery offers a potential solution to enhance students' well-being and academic performance. Attention Restoration Theory suggests that exposure to nature and natural elements helps in recovering mental fatigue and restoring directed attention (Kaplan, 1995; Bagot et al., 2015). Stress Recovery Theory emphasizes the immediate positive affective and physiological responses, such as relaxation, when exposed to plants and nature-based characteristics (Ulrich et al., 1991). By creating a restorative indoor environment, indoor plants, and greenery can contribute to the cognitive, emotional, and overall psychological well-being of students.

3. Methodology

This exploratory research utilizes a mixed-method approach, combining quantitative and qualitative data collection and analysis. The quantitative aspect involves employing a questionnaire called SACRA-15/building well-being scale to measure participants' hedonic and eudaimonic well-being levels, as well as overall psychological well-being. The questionnaire assesses dependent variables, while the independent variables focus on indoor green spaces, including the amount of greenery and its positioning in relation to the subjects. The qualitative method involves a personalized questionnaire to evaluate preferences, answers, and suggestions regarding three types of indoor green spaces and the amount of natural light exposure. The research was conducted online due to Covid 19 pandemic restrictions, involving 36 final-year Architecture students from the University of Moratuwa, Sri Lanka. Participants experienced simulated 3D videos online, representing five different interior conditions related to the independent variables. Data was analysed using SPSS and manual methods. The findings, conclusions, and recommendations provide insights for designing indoor green spaces to enhance users' psychological well-being.

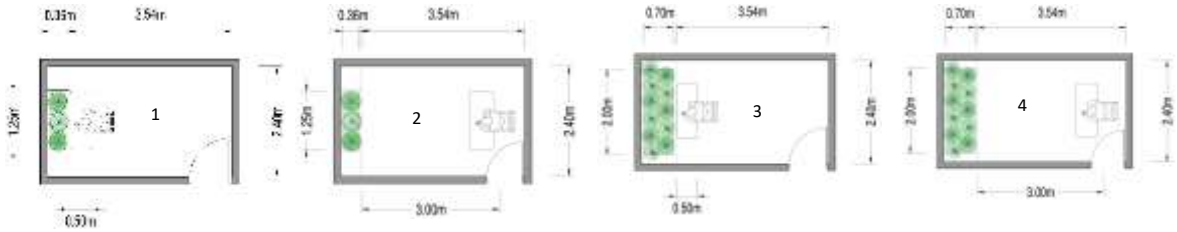
3.1. EXPERIMENTAL SETUP

This study adopted the minimum dimensions for habitable internal spaces in residential buildings specified by the Urban Development Authority of Sri Lanka in 2005 as a foundation for designing a virtual indoor experimental space. These minimum standards include a room area of at least 8.5 square meters, a minimum width of 2.4m (*3.54m length), and a minimum height of 2.7m. The study allocated additional floor space for integrating green elements in various scenarios. The design of the space was intentionally minimalist, devoid of architectural features like windows, opening etc., and decorated in neutral white tones (Samimi, 2020). This was done to ensure that the participants' psychological well-being remained unaffected by external factors and to focus solely on the impact of indoor plants. While UDA regulations recommend having an opening or window in a room, the study intentionally omitted this feature to avoid any potential distractions from outdoor visuals and varying light conditions. If a window were included near the plants, it could disrupt the participants, and a blind or curtain would need to be added, essentially recreating the same conditions as a windowless setup. To represent green spaces within this controlled environment, the study incorporated a combination (mixture) of popular indoor plants from Sri Lanka, such as Dwarf Umbrella, Chinese Evergreen, and Orange Jessamine to represent different green tones and leaf sizes. These plants were chosen because they thrive in daylight conditions and can grow with artificial UV lighting, eliminating the need for direct sunlight.

3.2. SCENARIO IDENTIFICATION FOR PARTICIPANTS

Green cover ratio (GCR) was considered as the amount of floor area covered by the greenery foliage with respect to the total floor area of the room. The Rural Development Administration of South Korea recommends their residence to have minimum of 0.33m^2 of indoor green cover per 6m^2 of floor area (GCR of 5.5%) without solely having an artificial environment (Kim et al., 2013). Due to the lack of specific local regulations and world research on interior greenery, 5.5% is adopted as the minimum, with 16.5% as the maximum as the highest ratio should be at least three times as the lowest (Han, 2019). To the simulated experimental room with 8.5m^2 total floor area, greenery is added using plant beds with 0.46m^2 for the minimum GCR and 1.40m^2 for the maximum. The study used plant beds as a type of indoor green space with various indoor plants as mentioned above to meet specified green cover ratios in different scenarios. This helped achieve a plant height of approximately 1m, considering the typical eye level of a seated person is about 1.1m above the ground (Gong, 2000). Interior green spaces were positioned against a wall at one end of the simulated indoor 3D space and the student's activity location (experiencing position) was positioned in relation to the green space as closest distance (1m range) and furthest distance (3-3.5m range). After a pilot study, improved Simulated 3D Videos of controlled setup & four main scenarios were experienced by the participants for a set duration in a regular specific time on separate days for assessments. Apart from the main study, participant preferences for different types of interior green spaces (courtyard, plant bed, potted plants) and the amount of exposure of the green

space to the natural light from top (full-100%, partial-50%, none-0%) were also studied separately to get an idea on general preferences.



1. *Scenario 1 – Low greenery at a close distance*
2. *Scenario 2 – Low greenery in a further distance*
3. *Scenario 3 – High greenery at a close distance*
4. *Scenario 4 - Low greenery in further distance*

Figure 3, The scenarios followed within the study *(Source: Author)*

Figure 4, Still Images of 3D Simulated Experimental Setups *(Source: Author)*

1. *3D Simulated experimental Setup for Learning environment without any greenery* ***(Controlled Condition)***
2. *3D Simulated experimental Setup for a Learning Environment with Low greenery at a close distance* ***(Scenario 1)***
3. *3D Simulated experimental Setup for a Learning Environment with Low greenery at a far distance* ***(Scenario 2)***
4. *3D simulated experimental Setup for a Learning environment with High greenery at a close distance* ***(Scenario 3)***
5. *3D simulated experimental Setup for a Learning environment with High greenery at a further distance* ***(Scenario 4)***

3.3. SUBJECTIVE MEASUREMENTS OF PSYCHOLOGICAL PERCEPTIONS

This study utilized two questionnaires to measure participants' psychological well-being and preferences. The first questionnaire, SACRA-15, assessed psychological well-being in terms of satisfaction, positive affect, competence, relatedness, and autonomy. The second questionnaire, PQ, collected data on preferences, suggestions, and participant demographic information. The data analysis involved using both SPSS software and manual methods to examine the relationships and connections between the variables studied.

4. Data Presentation And Analysis

4.1. PILOT STUDY

A pilot study was conducted with 7 Architecture students. Different scenarios were tested over 5 days, and it was revealed that the presence of greenery improved psychological well-being compared to a controlled space. Based on the suggestions for amendments further experiments were conducted.

4.2 EXPERIMENTAL CONTROLLED SETUP OF THE MAIN STUDY

In the experiment, controlled conditions were created in a room without any greenery, only containing a working table and chair. The participants' psychological well-being levels were found to be low, with a majority experiencing low well-being (77.78%) and a significant number showing signs of very low well-being (22.22%). The results of the experiment showed lower mean scores for participants' well-being across all five SACRA items in the control condition. The component of hedonic well-being called "relatedness" had the lowest mean score (4.81 out of 15), while the component of eudaimonic well-being called "autonomy" had the highest mean score (6.19). This indicates that both hedonic and eudaimonic well-being levels were negatively affected in control condition, scoring only around 35-37% of the total score.

4.3 PSYCHOLOGICAL WELL-BEING WITH RELATION TO AMOUNT OF INDOOR GREENERY.

In closer distance (Scenario 1 vs Scenario 3) - Introducing indoor greenery significantly improved participants' psychological well-being, even with a low amount of greenery. Higher levels of indoor greenery led to greater enhancement in well-being. The high greenery condition improved well-being for approximately 25% of participants and provided moderate to very high well-being levels for 91.67% of participants. High greenery levels were found to positively impact on well-being scores across all components, with the greatest improvement observed in Affect (+1.89 points) and the least in relatedness (+1.05 points). Increasing greenery boosted hedonic well-being by +11.5% and eudaimonic well-being by +7.96%, resulting in higher hedonic well-being (69.93%) compared to eudaimonic well-being (66.53%) in areas with more greenery.

Table 1: Score percentages for hedonic and eudaimonic well-beings for comparative scenarios

	Components	Mean Score	Total score	Score percentage	Well-being
Low greenery (5.5% green cover ratio)	Satisfaction	8.61	17.53	58.43%	Hedonic well-being
	Affect	8.92			
	Competence	8.75	26.36	58.57%	Eudaimonic Well-being
	Relatedness	8.39			
	Autonomy	9.22			
High greenery (16.5% green cover ratio)	Satisfaction	10.17	20.98	69.93%	Hedonic well-being
	Affect	10.81			
	Competence	9.94	29.94	66.53%	Eudaimonic Well-being
	Relatedness	9.44			
	Autonomy	10.56			

Scenario 1 vs Scenario 3

	Components	Mean Score	Total score	Score percentage	Well-being
Low greenery (5.5% green cover ratio)	Satisfaction	7.89	15.78	52.60%	Hedonic well-being
	Affect	7.89			
	Competence	8.14	23.50	52.22%	Eudaimonic Well-being
	Relatedness	7.28			
	Autonomy	8.08			
High greenery (16.5% green cover ratio)	Satisfaction	11.08	22.72	75.73%	Hedonic well-being
	Affect	11.64			
	Competence	11.39	33.32	74.04%	Eudaimonic Well-being
	Relatedness	10.39			
	Autonomy	11.54			

Scenario 2 vs Scenario 4

At far distance (scenario 2 vs scenario 4) - This investigated the effects of indoor greenery on psychological well-being within a range of 3m to 3.54m. Participants were exposed to varying levels of indoor greenery, from low to high. The findings revealed that higher levels of indoor greenery significantly improved participants' psychological well-being. While the low greenery condition had individuals with low well-being levels, the high greenery condition had none. Increasing the presence of greenery had a positive impact on psychological well-being, with 61.11% of participants in the high well-being level and 5.56% in the very high well-being level. Having a substantial amount of greenery indoors enhanced the psychological well-being of 91.67% of participants, affecting various well-being aspects positively, particularly positive feelings and personal abilities. This highlighted the importance of creating a familiar environment for participants during experiments and noted that relatedness scored lowest in all conditions. Regarding hedonic and eudaimonic well-being, low greenery conditions at a far distance had a similar effect on both levels. However, increasing greenery led to greater positive feelings, reduced negative feelings, and a slightly greater increase in hedonic well-being compared to eudaimonic well-being in the high greenery condition.

4.4 PSYCHOLOGICAL WELL-BEING IN RELATION TO OBSERVING DISTANCE

In Low greenery level (Scenario 1 vs Scenario 2) - This explored the effects of indoor greenery on participants' psychological well-being at different distances. Increasing the amount of indoor greenery generally improved participants' well-being, regardless of the distance. However, when the amount of greenery was constant, well-being decreased as the observing distance increased in the low green condition. Around 25% of participants experienced a decrease in well-being, with no participants reporting high well-being levels in the far-distance scenario. In the close-distance scenario, the percentage of participants with low and moderate well-being levels increased. The study identified autonomy as the most affected well-being component, while competence was the least affected. Despite a decrease in scores for all well-being components, the decrease was less pronounced compared to control conditions, indicating that even a small amount of indoor greenery can enhance psychological well-being. Comparing close and far distances, both hedonic and eudaimonic well-being were similarly affected by the increase in distance in low indoor greenery conditions, resulting in a comparable decrease.

Table 2: Score percentages for hedonic and eudaimonic well-beings for comparative scenarios

	Components	Mean Score	Total score	Score percentage	Well-being
Close Distance (0-1m range)	Satisfaction	8.61	17.53	58.43%	Hedonic well-being
	Affect	8.92			
	Competence	8.75	26.36	58.57%	Eudaimonic Well-being
	Relatedness	8.39			
	Autonomy	9.22			
Far Distance (3m – 3.54m range)	Satisfaction	7.89	15.78	52.60%	Hedonic well-being
	Affect	7.89			
	Competence	8.14	23.50	52.22%	Eudaimonic Well-being
	Relatedness	7.28			
	Autonomy	8.08			

Scenario 1 vs Scenario 2

	Components	Mean Score	Total score	Score percentage	Well-being
Close Distance (0-1m range)	Satisfaction	10.17	20.98	69.93%	Hedonic well-being
	Affect	10.81			
	Competence	9.94	29.94	66.53%	Eudaimonic Well-being
	Relatedness	9.44			
	Autonomy	10.56			
Far Distance (3m – 3.54m range)	Satisfaction	11.08	22.72	75.73%	Hedonic well-being
	Affect	11.64			
	Competence	11.39	33.32	74.04%	Eudaimonic Well-being
	Relatedness	10.39			
	Autonomy	11.54			

Scenario 3 vs Scenario 4

In High greenery level (Scenario 3 vs Scenario 4) – Observing distance impacts the relationship between indoor greenery and psychological well-being. Increasing distance boosts well-being levels, especially for eudaimonic well-being. Competence shows the highest increase and other well-being components also were found to be improved. High indoor greenery at a far distance has a significant effect on enhancing well-being. Hedonic and eudaimonic well-being become almost equal at a greater distance. Overall, increasing the distance from indoor greenery improves psychological well-being, particularly in terms of eudaimonic well-being. Overall, the study suggests that observing distance plays a significant role in the relationship between indoor greenery and psychological well-being. Increasing the distance between individuals and indoor greenery can lead to higher levels of well-being, particularly in terms of eudaimonic well-being.

4.5 OVERALL RESULTS AND DISCUSSION

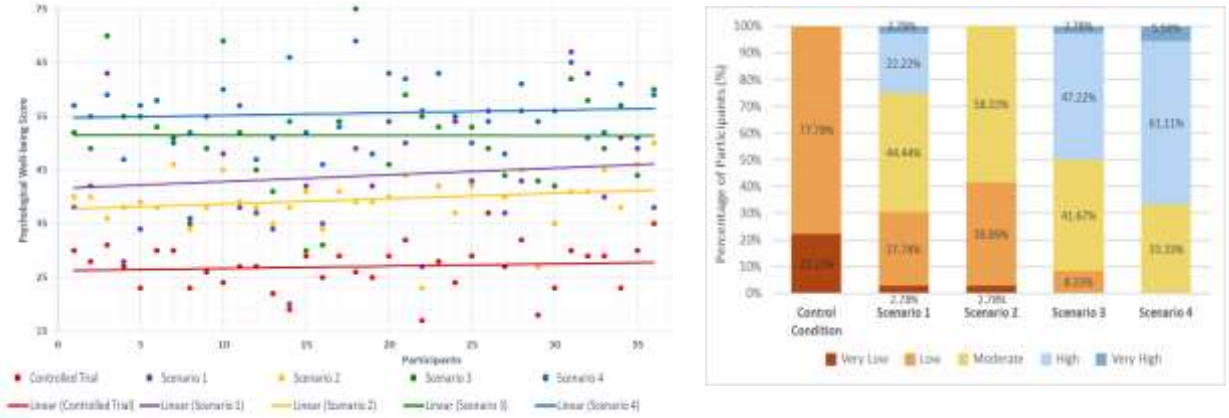


Figure 5, Psychological Well-being scores of all participants & Percentage of participants in all 5 conditions

The study examined the impact of indoor greenery on the psychological well-being of participants. It compared different scenarios with varying levels of indoor green coverage ratio (GCR) and observed distances from the plants. The results indicate that psychological well-being is consistently enhanced when the indoor green coverage ratio is increased, regardless of the observing distance. However, a previous study by Han (2009) did not find a significant influence of the indoor green coverage ratio on participants' subjective psychological perceptions, possibly due to lower GCRs and a smaller gap between them. The current study attempted to overcome this limitation by selecting participants from different parts of the country, representing various climatic conditions, to minimize the impact of environmental factors.

The study finds that any amount of indoor greenery improves participants' average psychological well-being compared to a control condition without greenery. This aligns with findings from previous studies. Among the four scenarios tested, the highest psychological well-being levels are observed when there is a high amount of greenery (16.5% GCR) at a distance of 3-3.54m. This scenario has the highest overall well-being score and the most participants in higher well-being levels. When the observing distance is closer in the high greenery scenario, the percentage of participants with high well-being levels decreased, and some experienced low well-being levels. The hedonic well-being (satisfaction and positive feelings) is higher than the eudaimonic well-being (competence and relatedness) in this scenario. Nonetheless, experiencing high amounts of greenery at any distance was found to positively enhance both hedonic and eudaimonic well-being compared to low greenery scenarios. In low greenery conditions, the observing distance affected well-being differently. Experiencing low greenery at a closer distance led to better psychological well-being compared to a far distance. However, both hedonic and eudaimonic well-being are slightly lower in this scenario, with a greater reduction observed in eudaimonic well-being.

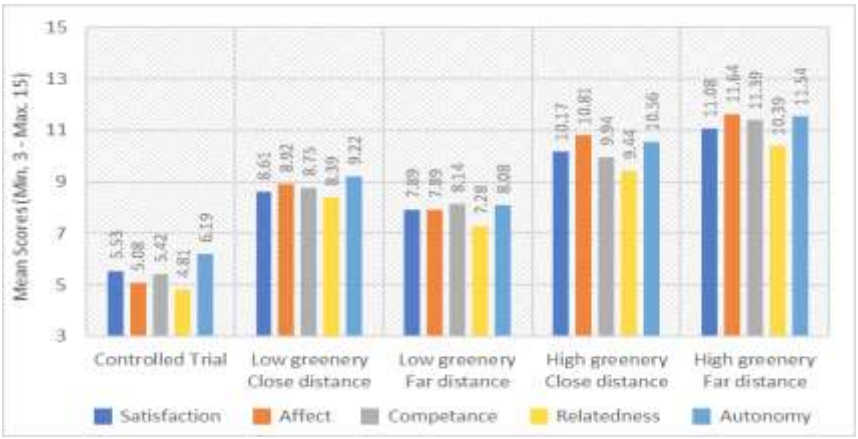


Figure 6, Mean average scores for SACRA components in all scenarios including controlled condition.

Table 3: Overall Score percentage for hedonic and eudaimonic well-being in all conditions

Psychological well-being Type	Overall Score Percentages			
	Low Greenery level		High Greenery level	
	Close Distance	Far Distance	Close Distance	Far Distance
Hedonic well-being	58.43%	52.60%	69.93%	75.73%
Eudaimonic well-being	58.57%	52.22%	66.53%	74.04%

Overall, the study suggests that high levels of indoor greenery are more effective for achieving positive psychological well-being than low levels. When adopting low greenery, placing functions closer to the green space improves psychological well-being levels. The importance of experimenting with a familiar condition is highlighted by the consistently low scores for the relatedness component of eudaimonic well-being. Table 3 provides an overview of the overall score percentages for hedonic and eudaimonic well-being in all the conditions tested. Hedonic well-being consistently scores slightly higher than eudaimonic well-being, primarily due to higher satisfaction and positive affect scores. However, if familiar indoor spaces had been used, participants' relatedness might have been improved, potentially leading to better eudaimonic well-being.

In conclusion, the study demonstrates that indoor greenery positively impacts psychological well-being. Increasing the indoor green coverage ratio enhances both hedonic and eudaimonic well-being, with satisfaction and positive feelings being more influenced. The findings suggest that incorporating high levels of indoor greenery in the design of spaces can contribute to students' overall psychological well-being.

4.6 PREFERENCES ON INDOOR GREEN SPACE: TYPES AND LEVEL OF EXPOSURE TO NATURAL LIGHT

In terms of natural light exposure, the majority of participants (over 58%) preferred partially exposing the indoor green space to natural light regardless of the amount of greenery or observing distance. Even in high greenery conditions, a significant number of participants (33.3% and 41.2%) preferred green space being fully exposed to natural light. Participants who preferred partial exposure, mentioned reasons such as shadow patterns among plants, a natural feeling with light, clear textures, and the fresh feeling of greenery with light. Regarding the type of indoor green space, more than 55% of participants preferred indoor courtyard as the green space type in all scenarios, regardless of greenery amount or observing distance. In high greenery conditions, the preference for courtyards was even higher, with 72.7% preferring a courtyard at a closer distance and 76.5% preferring it at a far distance. The only other type preferred in high greenery conditions was plant beds but to a lesser extent. In low greenery conditions, a considerable number of participants (35.3%) preferred plant beds at close distances, although the majority still preferred courtyards. Potted plants were only preferred by a few participants in low greenery conditions.

Participants who preferred indoor courtyards mentioned reasons such as having a more natural and open environment, creating a mini forest-like set up indoors, and providing a continuous connection with plants without separations or barriers. The sense of freedom, openness, vibrancy, and replicating the outdoor environment within indoor spaces were also common reasons for the preference for courtyards over other indoor green space types.

4.7 PROPOSED DESIGN GUIDELINES FOR INDOOR GREEN SPACES

The proposed design guidelines aim to enhance the psychological well-being of occupants in indoor green spaces. These guidelines serve as recommendations for designers to follow in creating such spaces in the future.

- Include courtyard-type indoor green spaces in the design.
- If it's not possible to have a significant amount of indoor vegetation, consider using plant beds.
- Allow natural light from above to expose the green space partially or fully.
- For larger indoor green spaces with high greenery levels, fully exposing them to natural light is recommended.
- Create large green spaces with high greenery levels and place user functions at a distance for better psychological well-being.
- If a long observing distance is not feasible, placing user functions closer to the green space is the second-best option.
- In small indoor green spaces with low greenery levels, position user functions as close as possible to improve well-being.
- Avoid placing user functions far away from small green spaces with low greenery levels.
- If none of the above options are possible, incorporate any kind and amount of greenery within the design's capabilities, rather than designing completely artificial indoor spaces.

These recommendations aim to enhance the well-being and psychological benefits of users by integrating green elements into indoor designs, promoting a connection with nature.

5. Conclusion

This study examined the impact of indoor greenery on the psychological well-being of occupants. It investigated the satisfaction, affect, competence, relatedness, and autonomy levels of individuals regarding the amount of green cover and observing distance from indoor plants in a simulated experimental setup. The findings indicated that high indoor greenery, especially when observed from a far distance, resulted in better psychological well-being, including higher satisfaction, positive feelings, personal control, and resilience. Even a few indoor plants were found to benefit well-being compared to no greenery, although low greenery at a far distance had the most negative impact. The effects of greenery and observing distance were similar for both males and females, with slightly more positive effects for females in high greenery conditions.

Apart from the main well-being findings, personal preferences revealed that most people preferred indoor courtyards as the type of green space and them being partially exposed to natural light as they create vibrant shadow patterns and enhance a sense of naturalness. However, a considerable number of individuals preferred plant beds with low greenery as indoor greenery type and high greenery spaces which are fully exposed to natural light from top. Therefore, these findings warrant greater attention and wider application in the field of architecture when designing indoor green spaces with an intension to provide good psychological well-being for occupants rather than designing them merely as aesthetic features.

6. Future Recommendations

This study provides an initiation to the research area of how the psychological well-being of people differ with relation to the indoor greenery amounts and observing distances by investigating only 4 scenarios at each end of each parameter to uncover basic relationships. It is recommended to investigate on a wider range of scenarios to establish comprehensive patterns and determine optimal values for indoor greenery and observing distances. Additionally, the study recommends examining the objective effects of indoor plants on physical environmental conditions like temperature, humidity, and air quality, as these factors can indirectly influence occupants' well-being. Furthermore, future studies could explore how indoor green spaces impact inhabitants' work performance, such as learning and productivity, and how these outcomes are affected by different design parameters and variables related to indoor greenery.

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