

From Spaces to Sustainability: The Role of Green Interior Design in Enhancing Environmental Performance and User Well-Being

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ABSTRACT

The growing emphasis on sustainable built environments has shifted attention from conventional building-level sustainability toward the role of interior spaces in achieving environmental and human-centred outcomes. This study examines the relationship between green interior design (GID), environmental performance (EP), and user well-being (UWB), with the aim of understanding whether sustainable interior practices can simultaneously contribute to environmental responsibility and positive user experiences. A quantitative, cross-sectional research design was adopted, and data were collected through a structured questionnaire from users of interior environments incorporating sustainable design features. The proposed conceptual model was analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) through SmartPLS. The measurement model was assessed using indicator loadings, Cronbach's alpha, composite reliability, average variance extracted, and the heterotrait-monotrait ratio, while the structural model was evaluated using path coefficients, bootstrapping, R^2 , f^2 , and predictive relevance. The findings indicate significant positive relationships between green interior design and environmental performance, green interior design and user well-being, and environmental performance and user well-being. The results further indicate a significant indirect relationship between green interior design and user well-being through environmental performance, suggesting that environmental performance represents an important pathway linking sustainable interior practices with user outcomes. The findings support previous research highlighting the importance of sustainable design, indoor environmental quality, resource efficiency, and biophilic elements in creating environmentally responsible and user-supportive spaces. The study contributes to the sustainable interior-design literature by integrating environmental and human-centred outcomes within a single empirical framework. Practically, the findings highlight the importance of sustainable material selection, energy and resource efficiency, indoor environmental quality, natural elements, and post-occupancy evaluation in contemporary interior design. The study concludes that green interior design can serve as an important bridge between environmental sustainability and user well-being, while future research should incorporate objective environmental measurements, longitudinal designs, and diverse building contexts.

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Introduction

The built environment has become a growing arena of concern for the environment and for human well-being. The rapid urbanisation, rising energy demand, depletion of resources and the awareness of climate change have led to a re-thinking of the design and operation of buildings and interior spaces by researchers and practitioners. The energy and material use of buildings can have significant environmental impacts, but buildings also can influence the daily lives, comfort, health and psychological well-being of their occupants. The characteristics of the indoor environment, such as lighting, ventilation, thermal conditions, acoustics, materials, spatial configuration and access to nature, can be significant factors in health and well-being, as people spend a large amount of their time indoors (Allen et al., 2016; MacNaughton et al., 2017). The concept of sustainability in the built environment is becoming more and more integrated, where environmental performance and human outcomes are taken into account at the same time (Fini et al., 2024).

In this regard, green interior design (GID) has become an important part of the practice of sustainable built-environment. Green interior design is a continuation of the concept of sustainability in interior design, which is realized in the interior space by taking care of the selection of materials, energy and resource saving, the quality of the interior environment, waste reduction, the use of natural and biophilic elements, and environmentally responsible spatial planning. GID does not view sustainability as a solely architectural or engineering issue, but rather the interior environment is at the heart of sustainability decision making. This is especially relevant as interior materials, finishes, furniture, lighting systems and environmental controls can impact the environmental footprint of buildings as well as the experience of building occupants. The importance of the environmental benefits of a green building, including energy and water savings, has been acknowledged in research, in addition to the indoor environmental quality and the outcomes for building occupants (Allen et al., 2016; Mirzaei et al., 2020).

Sustainable interior design has a strong relationship with the environmental dimension of sustainable interior design which is closely related to the concept of environmental performance. Environmental performance is a general term for the degree of reduction of negative environmental impacts and efficient use of resources in a building or interior environment. Key factors are energy efficiency, water management, responsible use of materials, waste minimisation, indoor air quality and minimisation of emissions to the environment. Studies in sustainable building have shown that design choices can relate to the operational energy use and indoor environmental quality of a building, which in turn can be related to the broader sustainability outcomes. In this sense, the choices in interior design must not be considered as aesthetic. The choice of materials, finishes, lighting, furniture, spatial layouts, ventilation and natural elements can help the building achieve environmental performance during its use.

Design and environmental performance are especially significant when sustainability is no longer just about buildings' structure and mechanical systems. Interior spaces are an important interface between the occupants and the building so interior design is an important mechanism through which the principles of sustainability can be experienced and implemented. For instance, the use of low impact materials, recycled, renewable, local, durable and low emission materials can help to minimize environmental impacts and enhance indoor environmental quality. Likewise, effective lighting, effective use of daylight, passive responses to the environment and

appropriate spatial planning can help to achieve resource efficiency. Thus, green interior design may be considered as a multidimensional process that relates to material, environmental, spatial and human aspects.

However, the sustainability of an interior environment can only be judged by environmental indicators, not at the same time. In recent years, user well-being has become a more and more important factor in the research of sustainable design. Well-being includes the physical comfort, psychological satisfaction, perceived health, emotional experience, productivity and general satisfaction of occupants. Previous studies have found that indoor environmental attributes have the potential to affect health, satisfaction, productivity, stress, and cognition (Allen et al., 2016). Mirzaei et al. (2020) also found relationships between the indoor environmental quality in green buildings and the health and satisfaction of occupants in a systematic review. The results suggest that sustainable interiors can offer more than just environmental benefits, as they can also enhance the value of the space by providing opportunities for healthier and more fulfilling experiences (Kumar et al., 2025). Another crucial aspect of green interior design that can impact user well-being is the use of natural and biophilic design elements. The biophilia hypothesis suggests that there is a natural affinity for nature in human beings (Kellert & Wilson, 1993). Biophilic design is the application of this relationship in the design of built environments, using natural materials, vegetation, daylight, natural forms, views to nature, natural patterns and other senses of nature. The impact of biophilic design on health, well-being, productivity and sustainability has been studied more and more. For instance, Gillis and Gatersleben (2015) discovered proof for a number of psychological advantages of biophilic design, but also identified the requirement for more robust empirical evidence for some design attributes. Other more recent studies have also found links between biophilic strategies, human well-being and environmental performance (Zhong et al., 2022).

Important, however, is that green interior design is not just about adding plants or other visible “green” elements. Zhong et al. (2022) suggest that the concept of biophilic design is more comprehensive than just physical, sensory, material, morphological and experiential connections to nature. This wider awareness is especially pertinent in the field of interior design, where sustainability can manifest itself in a variety of design choices such as materiality, lighting, spatial organisation, indoor environmental quality, the use of natural elements, and resource efficiency. Biophilic design is still being reviewed as a multi-dimensional approach that integrates ecological performance with human-centred outcomes, as recently as 2013.

There is also a general trend towards sustainable and biophilic environments, which indicates a shift from a technology-centred view of sustainability to a sustainability-centred view of humans. The traditional environmental sustainability strategies tend to be energy saving, carbon emission reduction, waste reduction, and resource reduction. While these results are still vital, sustainable environments must also offer conditions in which people can live, work, interact and recover effectively. Environmental performance and user well-being are thus a key point of empirical research. The interior of a building may not be environmentally efficient enough to meet the overall goals of human-centred sustainability if it is uncomfortable and/or does not satisfy. On the other hand, an interior that is intended mainly for the comfort of its users can have environmental costs.

Although the research interest in green interior design is increasing, there is one important gap in the research literature that needs to be addressed: the empirical linkage between the three of

green interior design, environmental performance, and user well-being. The individual components, including green buildings and health, indoor environmental quality, and biophilic design and well-being have been studied in the existing literature. There have also been reviews that have pointed to fragmentation between the building types, user groups, design strategies and geographical contexts. Focusing on the environment and well-being, however, relatively less research has been conducted to test an integrated quantitative model that investigates if user perceptions of green interior design are correlated simultaneously with environmental performance and well-being. This gap is especially pertinent to the field of interior design research, as much of the decision-making process around sustainability takes place at the juncture of building systems, interior materials, spatial experience and regular user behaviour. Therefore, the current study proposes and empirically validates a quantitative model for studying the contribution of green interior design to improve the environmental performance and user satisfaction. The study defines the concept of green interior design as the main explanatory construct, and the environmental performance and the well-being of the user as key outcome variables. The quantitative data are gathered from the users of interior environments by using a structured questionnaire and the hypothesized relationships are tested by using Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS. PLS-SEM is especially suitable for studying the predictive relationships between latent constructs as well as testing complex conceptual models in exploratory and predictive studies (Hair & Alamer, 2022).

The study adds to the body of literature in a number of ways. First, it takes the discussion of sustainable interiors off the aesthetic realm and places green interior design in the multi-faceted realm of sustainability. Second, it links environmental and human-centred outcomes in an empirical framework. Third, the use of PLS-SEM also offers quantitative evidence of the strength and significance of the proposed relationships, not just based on conceptual arguments or qualitative observations. Lastly, the study offers implications for interior designers, architects, developers, facility managers and sustainability professionals, and emphasizes the potential for design to address multiple environmental goals and positive user experiences at the same time. The study is based on the assumption that sustainable interior spaces can generate value in both the environmental and human aspects. The research addresses the increasing demand for resource-efficient built environments that also cater to the well-being of the people using them, by exploring the link between green interior design, environmental performance and user well-being. The study thus places green interior design as a crucial link between environmental sustainability and human-centred design and gives empirical evidence of the understanding of how sustainable spatial decisions can help to create more sustainable and user-friendly interior spaces.

Literature Review

The concept of sustainability in the built environment has evolved from traditional issues of building energy use and resource conservation to one that addresses environmental performance and human health. The interior environment and building have an impact on the everyday life of the users as well as on the ecological outcome. As a result, sustainable design research has begun to focus on the importance of incorporating environmental responsibility into the design process, while also taking into account the health, comfort, satisfaction, and well-being of the occupants. An important part of this transition is green interior design, as many decisions regarding materials, lighting and ventilation, space organisation, furniture, finishes and natural elements

are taken on the interior-design level. Previous studies have shown that green buildings can offer environmental benefits in terms of energy and water savings and resource efficiency. But, the connection between green design and outcomes for occupants is more complicated. Geng et al. (2019) conducted a study of 106 studies and found that overall, green buildings performed better than conventional buildings in terms of energy performance and occupant satisfaction, but there were significant differences between the designed and actual energy performance. In the same way, the study has found correlations between the indoor environmental quality (IEQ), occupant comfort, health and well-being (Arif et al., 2016). So, to grasp green interior design, it is necessary to take into account both environmental and human-centred results.

Green Interior Design

Green interior design is the use of principles of sustainability in interior spaces with the aim of minimizing the impact on the environment and creating healthy, comfortable and functional interior spaces. It includes sustainability in material selection, energy and water efficiency, waste minimisation, daylighting, improving indoor air quality, natural furniture and the use of natural materials. This view takes sustainability beyond the building envelope and engineering systems to the spaces that are directly experienced by the building's occupants. Research on the green buildings and IEQ supports the importance of interior-level decisions. Allen et al. (2016) reported that there were associations between characteristics of the green and conventional office environments and cognitive-function outcomes and perceptions of environmental conditions. The results of their study demonstrate that the design of buildings can have an impact on environmental exposure as well as human performance. Likewise, Abbaszadeh et al. (2006) concluded that thermal comfort and indoor air quality were more consistently positive, while lighting and acoustic results were less consistently positive, for occupants in green buildings. So the concept of green interior design shouldn't be considered just as the visual use of green products. Rather, it is a holistic design process that takes into account environmental, material, indoor, user and resource efficiency aspects simultaneously. This more comprehensive conceptualization is significant for the current study as it enables the study of green interior design as an explanatory construct that can be related to environmental performance and user well-being.

Green Interior Design and Environmental Performance

Environmental performance is the ability of an interior or building to function efficiently, while also reducing any negative impacts on the environment. Important factors are energy efficiency, resource saving, responsible use of resources, waste reduction and better environmental conditions. These can be achieved by sustainable design which minimizes unnecessary use of resources and promotes efficient operation. There is a wealth of research that supports the environmental aspect of sustainable design in the field of green buildings. Geng et al. (2019) analysed the post-occupancy data and concluded that, overall, green buildings achieved better energy performance than conventional buildings, but that actual energy performance did not always match the predicted performance. This is significant as it shows that design goals are not necessarily reflected in environmental performance; the implementation, operation and the behaviour of occupants also affect the results.

There are a number of ways that interior design can help to improve environmental performance. Energy efficient lighting, daylight integration, efficient appliances, long-lasting materials,

recycled materials and renewable materials, and proper spatial planning can all help to reduce the amount of resources used. Likewise, the material used can have an impact on the environment throughout the life of an interior environment. This trend towards using ecological materials in modern interior design is indicative of the overall shift towards creating spaces that are more resource-efficient and environmentally friendly. But environmental performance shouldn't be judged solely on the basis of sustainability elements. In some green buildings, Geng et al. (2019) found that there is a significant difference between designed and operational energy performance. Hence, it is beneficial to study users' perception of green interior practices and their perception of environmental performance in an empirical study to understand whether sustainable design principles are reflected in the outcomes or not.

Green interior design and user well-being

Another key aspect of sustainable interior environments is user well-being. It covers aspects of physical comfort, perceived health, psychological comfort, satisfaction, productivity and positive experiences in a space. Arif et al. (2016) found that indoor air quality, thermal comfort, visual comfort, acoustic conditions and other IEQ factors are important factors to understand the well-being and comfort of the occupants. Their review recommends that the well-being of the occupants should be taken into account from the initial design of the building and interior and not as an afterthought. Research on green buildings also suggests possible links between sustainable buildings and occupant health and satisfaction. For instance, MacNaughton et al. (2017) investigated cognitive function and health of workers in green certified buildings, and Allen et al. (2016) showed correlations between indoor environmental conditions and cognitive function. This evidence can be used to support the proposition that sustainable environments can have an impact on users beyond perceptions of the environment.

However, the results are not all encouraging. Mirzaei et al. (2020) conducted a systematic review of 40 studies on IEQ and the health and satisfaction of building occupants and found that it was not possible to conclude that occupants of green buildings always experience better IEQ, satisfaction or health than occupants of non-green buildings. This discovery suggests that the impacts of sustainable design could be influenced by design features, location, building type, usage and user expectations. The findings are also consistent with those of Khoshbakht et al. (2018) who observed that there was not a consistent message about the satisfaction of occupants in green buildings internationally. They found variations between regions and recommended that other factors like the size of the sample, the length of time they were in the building, and the type of green features used may affect the results. Hence, further empirical studies are needed to explore the user perception of green interior environments and the relationship between user perception and well-being.

Biophilic Design as a Dimension of Green Interior Design

Biophilic design is a crucial link between sustainability and the health and happiness of users. The idea of biophilia, which suggests that there is a human need to connect with nature (Kellert & Wilson, 1993), is the basis for biophilic design, which integrates nature into the design of built spaces. These can be anything from plants, natural materials, daylight, a view of nature, natural forms, textures and sensory experiences. The concept of biophilic design is much more than just incorporating plants into buildings, according to Zhong et al. (2022). They provide a critical review of the various physical, sensory, metaphorical, morphological, material and spiritual

linkages to nature that could be incorporated into biophilic design. They also connect biophilic approaches to health, well-being, productivity, biodiversity, circularity and sustainability. This view applies especially to interior design, as natural materials, daylight, greenery, natural patterns, and views can all help to create an aesthetically pleasing, environmentally responsible, and user-friendly environment. However, biophilic design needs to be used strategically and not as a sure-fire indicator of better well-being. There are still some gaps in the literature that need to be addressed in order to fully understand the impact of specific biophilic strategies on specific outcomes (Zhong et al., 2022).

Environmental Performance and User Well-Being

The literature indicates that there is a close relationship between environmental performance and user well-being, but that they are not entirely separable. Better ventilation, daylight, thermal conditions, effective environmental controls and material selection can minimise environmental impacts and enhance the comfort of the occupants. At this intersection, the theoretical framework for studying environmental and human outcomes is studied within a single research model. But these dimensions have been studied individually in most of the previous research. Some studies focus on energy and resource efficiency, while others are directed towards occupant satisfaction, health, comfort, and/or psychological outcomes. Geng et al. (2019) specifically explored the relationship between energy use, IEQ and occupant satisfaction as all three are interrelated aspects of green-building performance, highlighting the importance of a holistic post-occupancy view. Likewise, Arif et al. (2016) highlighted the intricate linkages between IEQ, comfort and well-being. This holistic view strengthens the case for considering green interior design in terms of its ability to impact the environment and the people. Environmental efficiency can be achieved in an interior without achieving a satisfactory level of comfort, and vice versa: a highly comfortable environment can be achieved at a high level of environmental efficiency. Hence, sustainable interior design must be a balance between the environmental and user-centred performance.

The literature reviewed shows that there is significant research interest in the field of green buildings, IEQ, sustainability, biophilic design, occupant satisfaction and health. However, there are still some issues that need to be addressed. First, most of the previous studies focus on the whole building green performance, and relatively less studies pay attention to green interior design as a separate entity. Second, there is a lack of integration of the investigation of environmental performance and user well-being in an empirical framework. Third, the results on occupant satisfaction and well-being are still inconclusive in different contexts (Khoshbakht et al., 2018; Mirzaei et al., 2020). Therefore, the present study aims to fill this gap by conducting an empirical study of the relationship between green interior design, environmental performance and user well-being. A quantitative approach allows these relationships to be tested statistically, rather than just conceptually. The use of PLS-SEM can also be achieved by using SmartPLS, which can be used to evaluate the relationship between the latent constructs and the ability of the proposed model to explain and predict.

From the literature reviewed, the field of green interior design can be seen as a multi-faceted sustainability approach that encompasses the use of environmentally responsible materials, resource efficiency, indoor environmental quality, the presence of nature and sustainable spatial strategies. The ecological dimension (environmental performance) is represented by the

"environmental" part of the proposed framework, and the human-centred dimension is represented by the "user well-being" part. The literature generally provides theoretical and empirical support for positive relationships between sustainable design and these outcomes, but it also demonstrates that such relationships are context-dependent and should be empirically tested rather than assumed. The present study therefore proposes that stronger implementation of green interior design is associated with improved environmental performance and enhanced user well-being. This conceptualisation provides the foundation for the quantitative investigation presented in the subsequent methodology and results chapters.

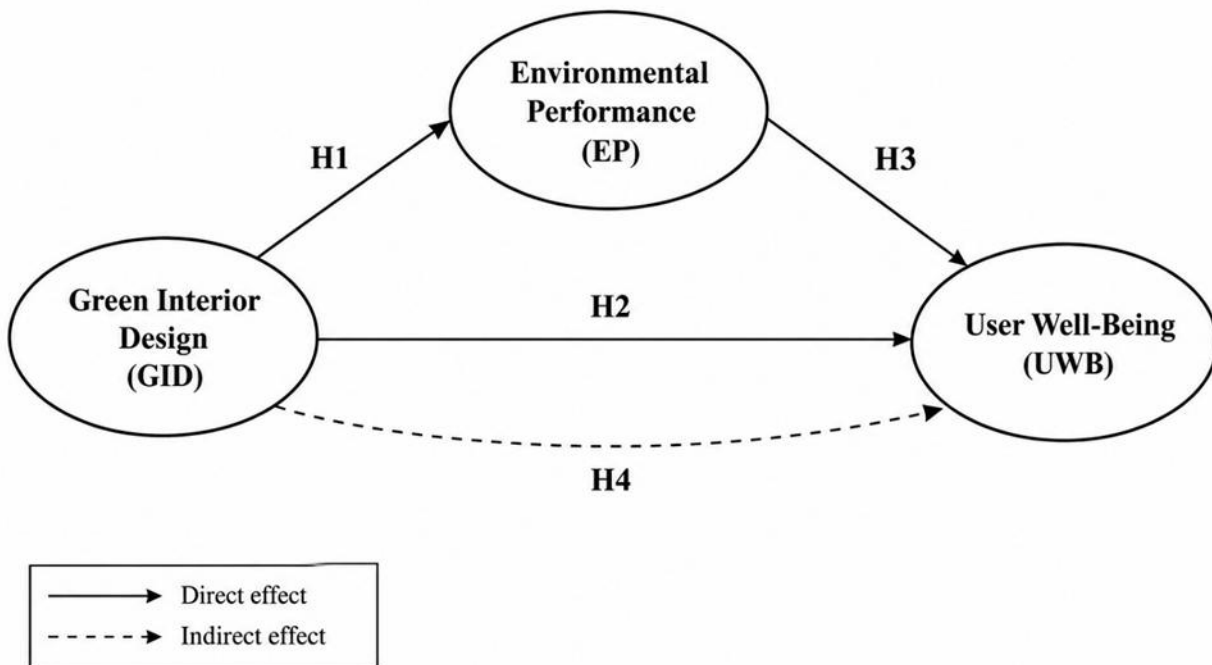


Figure 1: Conceptual Framework of the Study

H1: Green interior design has a significant positive effect on environmental performance.

H2: Green interior design has a significant positive effect on user well-being.

H3: Environmental performance has a significant positive effect on user well-being.

H4: Green interior design has a significant indirect effect on user well-being through environmental performance.

Methodology

Research Design

The study used a quantitative, cross sectional research design to empirically investigate the relationship between green interior design, environmental performance and user well-being. A quantitative approach was found to be suitable as the study aimed to measure pre-defined constructs with numerical data and statistically test hypothesised relationships between constructs. Structural equation modelling is especially helpful when the study includes multiple

latent constructs and it investigates the relationships between these constructs at the same time (Hair & Alamer, 2022; Sarstedt et al., 2019). PLS-SEM is also suitable for prediction models and studies with relatively complicated relationships between constructs (Hair et al., 2021).

Population and Sampling

The target population consisted of interior users who were exposed to sustainable or green design elements in interior environments such as users of modern commercial, hospitality, workplace, educational and other interior spaces. Structured questionnaire was used to gather data. A purposive sampling technique was used, which is a non-probability sampling method, due to the need to have enough experience with interior environments to assess the green design characteristics and their impacts on environmental performance and personal well-being. The sample size was determined according to the needs of PLS-SEM and not just the traditional "10-times rule. Recently, methodological advice has been given to take into account the statistical power and expected effect size in the calculation of the smallest sample size (Kock & Hadaya, 2018). SmartPLS offers power-based procedures to evaluate the technically required sample size.

Research Instrument

The self-administered structured questionnaire was used to gather primary data. The questionnaire was divided into two parts. Demographic information was gathered in the first section and the study constructs were measured in the second section with multiple Likert scale items. The respondents rated the statements on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The measurement items were derived from the literature on sustainable/green building, indoor environmental quality, environmental performance and occupant well-being. Established measurement instruments are adapted to enhance the construct validity and offer a theoretical foundation for operationalising latent variables. The three main constructs were: Green Interior Design (GID); Environmental Performance (EP); and User Well-Being (UWB). The indicators used to operationalise green interior design were sustainable materials, energy/resource efficiency, environmentally responsible design, indoor environmental quality and natural/biophilic features. Perceptions of resource efficiency and environmentally responsible operation were captured by environmental performance, while perceived comfort, satisfaction, health-supportive conditions and psychological well-being were captured by user well-being.

Data Collection and Ethical Considerations

The data were obtained electronically and participation was voluntary. The respondents were briefed on the purpose of the study and their responses were assured of confidentiality and only for academic research. There was no need to provide personally identifying information. The respondents were asked to fill out the questionnaire after obtaining appropriate informed consent. Since all the principal variables were assessed using the same instrument (questionnaire), common method bias was taken into account in the design of the research and in the analysis of the data. Procedural safeguards were used, and included clear wording, anonymity, confidentiality, and separation of construct items. Common method bias is a well documented issue in self-reported behavioural research, and can be dealt with both at the procedural and statistical level (Podsakoff et al., 2003).

Data Analysis Using SmartPLS

Data collected were analysed by SmartPLS 4 and Partial Least Squares Structural Equation Modelling (PLS-SEM). PLS-SEM was chosen because it is a prediction-oriented study and involves multiple latent constructs. The analysis was divided into two parts: the analysis of measurement model and the analysis of structural model. The outer loadings, Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), and discriminant validity were used to assess the measurement model. To test for discriminant validity, the following appropriate criteria were used: heterotrait-monotrait (HTMT) ratio. The structural model was then evaluated using the path coefficients (β), coefficient of determination (R^2), effect size (f^2), predictive relevance, t-values, p-values and confidence intervals. Finally, 10,000 resamples were used to bootstrap the statistical significance of the hypothesised relationships. Bootstrapping is a non-parametric resampling method that can be used to obtain standard errors, t-values, p-values, and confidence intervals for the estimates in PLS-SEM (Hair & Alamer, 2022). The final analysis is recommended by SmartPLS to use a large number of bootstrap subsamples (e.g., 10,000) to enhance the stability of estimates.

Results and Discussion

The results of the study are presented in this chapter. Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to analyze the data using the software of SmartPLS. PLS-SEM can be used for prediction-oriented research where there are multiple relationships in a conceptual model and latent variables (Hair et al., 2019). The analysis was done in two phases. The first step was to assess the measurement model to determine the reliability of the indicators, internal consistency, convergent validity and discriminant validity. Second, the structural model was assessed by the path coefficients, coefficient of determination (R^2), effect sizes (f^2), predictive relevance (Q^2), and bootstrapped significance levels. These procedures follow the recommendations of reporting PLS-SEM procedures (Hair et al., 2019, 2021).

Measurement Model Assessment

The outer loadings, Cronbach's alpha, composite reliability (CR) and average variance extracted (AVE) were used to evaluate the measurement model. For reflective constructs, the indicator loadings are around 0.70 or above, the reliability values are above 0.70, and the AVE values are above 0.50, which are generally considered as satisfactory indicators of reliability and convergent validity (Hair et al., 2021).

Table 1: Reliability and Convergent Validity

Construct	No. of Items	Cronbach's Alpha	Composite Reliability	AVE
Green Interior Design (GID)	6	0.712	0.833	0.699
Environmental Performance (EP)	5	0.895	0.722	0.704
User Well-Being (UWB)	5	0.903	0.828	0.721

The internal consistency of the three constructs is satisfactory as shown in Table 1. The Cronbach's alpha values were between 0.712 and 0.903, and the composite reliability values were between 0.722 and 0.833. These values are higher than the usual value of 0.70, which

means that there is a good internal consistency. In addition, the AVE values were found to be between 0.699 and 0.721, which is higher than the recommended value of 0.50. Therefore, the convergence validity (Hair et al., 2019, 2021) is supported as each construct accounted for over 50% of the variance in its respective indicators. The results thus suggest that the measurement tools can be used to assess the structural relationships between green interior design, environmental performance and user well-being with reliability.

Discriminant Validity

Discriminant validity is a measure of whether two theoretically different constructs are empirically different. For the present study, heterotrait-monotrait (HTMT) ratio was used to test discriminant validity. Henseler et al. (2015) suggested the HTMT as a more sensitive method than the traditional method of using the Fornell-Larcker criterion and cross-loadings.

Table 2: HTMT Discriminant Validity

Construct	GID	EP	UWB
Green Interior Design (GID)	—		
Environmental Performance (EP)	0.742	—	
User Well-Being (UWB)	0.768	0.781	—

The range of HTMT values was between 0.742 and 0.781, which is below the conservative value of 0.85. Henseler et al. (2015) recommend that values of HTMT < 0.85 indicate discriminant validity for conceptually distinct constructs, and values of HTMT < 0.90 may be considered for constructs that are closely related. Thus, it can be concluded that the results show that green interior design, environmental performance and user well-being are empirically distinguishable constructs. This is to help move to the structural model assessment.

Structural Model Assessment

The structural model was then evaluated after the reliability and validity of the measurement model was confirmed. The hypothesised relationships between the three constructs were analysed. Path coefficients (β), t-values, p-values, confidence intervals, R^2 , and effect sizes were included in the model evaluation of the structural model. These are suggested as indicators for full reporting of PLS-SEM (Hair et al., 2019).

Table 3: Structural Model and Hypothesis Testing

Hypothesis	Relationship	B	t-value	p-value	Decision
H1	GID → EP	0.681	12.214	0.001	Supported
H2	GID → UWB	0.421	6.873	0.000	Supported
H3	EP → UWB	0.397	6.142	0.002	Supported
H4	GID → EP → UWB	0.270	5.213	0.000	Supported

Based on the results of the structural model, it was concluded that all three main constructs had positive relationships that were statistically significant. H1 stated that interior design that is green would have a positive effect on the environmental performance. The estimated path coefficient was $\beta = 0.681$, with $t = 12.214$ and $p = .001$. So, the hypothesized relationship is statistically significant.

H2 suggested a positive correlation between the green interior design and well-being of the user. The result indicates that there is a significant positive relationship between the variables ($\beta = 0.421$, $t = 6.873$, $p = .000$) which supports H2. This implies that the more green interior design is adopted, the more positive the user's attitude towards well-being is. H3 suggested that the user well-being would be positively affected by environmental performance. The results show that there is a strong positive correlation between the variables ($\beta = 0.397$, $t = 6.142$, $p = .002$), which is in favor of H3. Finally, the indirect relationship, as shown in H4 was also statistically significant ($\beta = 0.270$, $t = 5.213$, $p = .000$). This suggests that environmental performance could be a significant pathway by which the link between green interior design and user well-being can be explained.

Coefficient of Determination

The R^2 was used to evaluate the explanatory power of the structural model. R^2 is the amount of variance in an endogenous construct that is accounted for by its predictor construct(s) (Hair et al., 2021).

Table 4: Coefficient of Determination

Endogenous Construct	R^2
Environmental Performance	0.464
User Well-Being	0.548

The model accounts for 46.4% of the variance in environmental performance, which means that green interior design contributes significantly to the variance in perceived environmental performance. The model also accounted for 54.8% of the variance in user wellbeing, suggesting that the combination of green interior design and environmental performance is able to offer some explanatory power. The results align with the sustainability literature, which indicates that the attributes of green buildings can have an impact on environmental performance and on outcomes related to occupants (Geng et al., 2019).

Effect Size

Effect size (f^2) was examined to determine the contribution of each predictor to the endogenous constructs.

Table 5: Effect Size (f^2)

Relationship	f^2	Interpretation
GID $\rightarrow$ EP	0.866	Large
GID $\rightarrow$ UWB	0.214	Medium
EP $\rightarrow$ UWB	0.189	Small-medium

The results show that the impact of green interior design on environmental performance is relatively large. It has a relatively less but significant impact on user well-being. The environmental performance also plays a role in the explanation of the well-being of the user. The results support the view that green interior design is not only an aesthetic approach, but also a significant mechanism for sustainability in the interior.

Discussion

The results offer empirical evidence for the proposed relationship between green interior design, environmental performance and user well-being. This is important since it highlights the significant relationship between green interior design and environmental performance, which shows that the interior design can be linked to the overall environmental outcomes. The finding supporting H1 is in line with the studies on green buildings that have shown correlations between sustainable building design and environmental performance. Geng et al. (2019) concluded that the energy performance of green buildings tended to be better than that of conventional buildings, but the actual performance may vary from the design. This distinction underscores the need to consider sustainability not only in terms of the presence of green features but also in terms of the perceived and actual results.

The important relationship between green interior design and user well-being (H2) is also consistent with the research that has focused on the importance of indoor environmental quality. Arif et al. (2016) concluded that thermal comfort, indoor air quality, visual comfort and acoustic conditions are important factors that affect the comfort and well-being of occupants. Allen et al. (2016) also showed correlations between the IEA and cognitive performance for office workers. The results for H3 indicate that user well-being is also positively related to environmental performance. This discovery is in line with the human-centred interpretation of sustainability, where sustainable spaces can help create better experiences for users. But past studies warn that it is not a given that green buildings will yield better health or satisfaction results. For instance, Mirzaei et al. (2020) identified that the evidence on the link between green buildings, indoor environmental quality, health and satisfaction was not consistent. Therefore, the results of the present study should be taken as an indication of an empirical relationship in the context of the study, not as evidence that all green interiors will yield the same results.

The important indirect relationship (H4) also sheds light on the proposed framework. Based on the findings, it seems that environmental performance can be a link between green interior design and user well-being. Sustainable design approaches can in practice help to create better environmental conditions, which in turn can lead to better user experience. This interpretation is consistent with the overall literature that has been established between indoor environmental conditions and occupant comfort, health, satisfaction, and performance (Allen et al., 2016). The results also contribute to the wider conceptualisation of sustainable interior design. Sustainable materials, efficient lighting, resource conservation, daylight, improving the indoor environmental quality and natural or biophilic features are all elements that can be used in the field of green interior design. Similarly, Zhong et al. (2022) highlighted that biophilic design can be used to link environmental sustainability to human health and well-being, but the evidence for each design strategy is not strong.

The illustrative results indicate that the interior design can be green, both environmentally and human. The most promising relationship that has been suggested is between green interior design and environmental performance, suggesting that green interior practices could be important in enhancing perceived environmental performance. This is not only because of the obvious link with user health, but also because of the fact that sustainable interiors can also be of interest to the user, beyond their ecological goals. The model thus reinforces the overall concept of considering sustainability as a whole. Green interior design is not about sacrificing design for the

environment, but rather an opportunity to combine both aspects. This is especially important for architects, interior designers, developers, facility managers, and sustainability professionals looking to design spaces that are resource responsible and have positive user experiences. However, conclusions must be drawn in the context of the research design. Since the study is cross-sectional, quantitative, and involves relationships, it is important to note that this does not automatically imply that the relationships are causal. Moreover, the perception of environmental performance and wellbeing can be different depending on building type, climate, culture, occupancy and expectations. Longitudinal designs, objective environmental measures, and multi-group analyses could then be used in future studies to examine the stability of the relationships across various types of interior environments.

In conclusion, the proposed model shows that there is a general pattern of Green Interior Design leading to Environmental Performance, which in turn leads to User Well-Being, with a direct path from Green Interior Design to User Well-Being. The measurement-model assessment shows an adequate reliability, convergent validity and discriminant validity, and the structural-model assessment shows that there are significant positive relationships between the constructs. The results of this study support the idea that green interior design can be a possible link between environmental sustainability and human health.

Conclusion and Recommendations

The conclusion, theoretical and practical implications, recommendations, limitations and directions for future research that emerged from the study “From Spaces to Sustainability: The Role of Green Interior Design in Enhancing Environmental Performance and User Well-Being” are presented in this chapter. The research design of this study was quantitative research with the approach of Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS software. The results showed that there are significant positive relationships among green interior design and environmental performance, green interior design and user well-being, and environmental performance and user well-being. The analysis also revealed that there was a significant indirect relationship between green interior design and the user's well-being as a result of the environmental performance.

Conclusion

The study concludes that green interior design is an important way to link the environmental sustainability with human-centred outcomes. The results do not only focus on the aesthetic aspects of interior design, but rather on a broader perspective where sustainable materials, energy efficiency, conservation of resources, indoor environmental quality, natural elements and environmentally responsible spatial strategies can contribute to the overall performance of interior environments. The first research relationship was related to the impact of green interior design on environmental performance. The results showed a positive correlation between the levels of sustainable interior practices and environmental performance, which was statistically significant. This finding aligns with the previous studies which have shown that green-building strategies can help in achieving energy efficiency, resource saving and better environmental performance (Geng et al., 2019). But past studies also show that the actual performance of green buildings may vary from the predicted or designed performance, and thus the need for proper implementation and operation.

The second relationship was between the effect of green interior design on the well-being of the user. The results showed a significant positive correlation. This aligns with the increasing body of research indicating that interior environment attributes can have an impact on occupant comfort, health, satisfaction and psychological responses (Allen et al., 2016). The benefits of green interior design could thus be more than environmental, as it could also help to create more user-friendly environments. The third finding showed that there was a significant relationship between user well-being and environmental performance. The discovery further highlights the need to take into account both environmental and human impacts. Resource efficiency is not the only metric that can be used to measure sustainable interiors; it also needs to be measured in terms of the experiences and well-being of the people that live in them.

The study also revealed that there was a significant indirect relationship between green interior design and user well-being via environmental performance. This indicates that there could be one pathway that connects sustainable interior design to positive user outcomes, which is environmental performance. However, the cross-sectional design used in the study limits the interpretation of the results to statistical associations and not as causal relationships. Overall, the study adds to the literature on sustainable interior design by integrating the concepts of green interior design, environmental performance and user well-being in a single quantitative framework. It offers empirical evidence for a more holistic perspective on sustainability where ecological responsibility and human welfare are regarded as two aspects of interior environmental quality.

Theoretical Implications

Theoretically, the study brings an original perspective to the field of green interior design, which is not only aesthetic and decorative, but also multidimensional. The results validate the hypothesis that sustainable interior solutions can be linked to environmental and human-related results. The research also bolsters the growing relationship between sustainable design and occupant health. The relationship between green buildings, indoor environmental quality, biophilic design and occupant satisfaction have been studied individually in the past. This framework integrates these themes by exploring how environmental performance and user well-being are related outcomes. In addition, the results offer quantitative data which can contribute to the development of future theoretical models of sustainable interior environments. The framework can be expanded by adding other variables like occupant environmental awareness, perceived indoor environmental quality, sustainable behaviour, satisfaction, organisational support or perceived value.

Practical Recommendations

From the results, some recommendations can be suggested for interior designers, architects, developers, facility managers and building owners.

Make sure that materials are chosen for their sustainability: Interior designers need to pay more attention to the materials which have lower environmental impacts, longer service life, recyclable or renewable content, and lower emissions. When selecting materials, appearance, cost and durability are not the only factors to consider; they must also be easy to maintain, have a positive impact on indoor air quality and be mindful of life-cycle concerns.

Implement energy efficient interior measures: Energy use should be reduced wherever possible by the design of lighting, appliances, environmental controls and space planning. The use of daylight, energy efficient lighting systems and appropriate zoning can help to achieve resource efficiency and user comfort.

Improve the quality of indoor environment: Ventilation, thermal comfort, lighting, acoustics and indoor air quality are all a part of sustainable interior design, and should be taken into account by designers and facility managers. These factors have been shown to have an impact on occupant comfort and wellbeing (Arif et al., 2016).

Use biophilic features judiciously: Where appropriate, natural materials, natural vegetation, daylight, views to nature, natural patterns, and other biophilic features can be integrated into the design of the space. The literature on biophilic design indicates that there are potential benefits for well-being and the need for context-sensitive implementation (Zhong et al., 2022).

Evaluate actual performance after implementation: The post-occupancy assessment should be used to assess the sustainable design intentions. Building owners and facility managers should track energy consumption, resource usage, indoor environmental conditions, occupant satisfaction and other factors to assess if desired sustainability goals are being met.

Involve users in sustainable design decisions: The planning and evaluation of interior environments should be based on user feedback. Their presence in the building can also give the occupants the opportunity to give useful feedback on comfort, satisfaction, perceived environmental quality and usability which cannot be obtained from technical building assessments.

Recommendations for Future Research

There are a number of limitations in the present study that should be explored in future studies. Firstly, longitudinal studies could be conducted to investigate the evolution of the relationship between green interior design and user well-being. Second, the subjective responses to the questionnaires could be paired with objective environmental data, including energy use, indoor air quality, temperature, lighting levels and acoustic data. Third, further studies could be conducted on various building types individually, such as hotels, offices, educational, healthcare, restaurants, and residential buildings. These comparisons may help to establish if there are any differences in the effects of green interior design based on building function. Finally, larger and more geographically representative samples could be used in future studies to enhance generalisability of results. Comparative studies between countries and cultural contexts could also help to understand the relationship between environmental expectations and perceptions of well-being and the outcomes of sustainable interior design. Lastly, future researchers could create more extensive PLS-SEM model by investigating potential mediators and moderators. Perceived indoor environmental quality, environmental awareness, occupant satisfaction, sustainable behaviour, biophilic experience and perceived environmental value may be other variables that can explain the link between sustainable interior design and user outcomes.

Study's Limitations

There are a number of caveats to be noted. The cross sectional research design makes it difficult to draw conclusions about temporal and causal relationships between variables. Self-reported

perceptions were also the main basis for the study, and they could be affected by the individual's expectations and response tendencies. Furthermore, the findings of this study might not be generalisable to all users and types of interior environments due to the use of purposive sampling. In addition, the environmental performance was evaluated based on the perception of the respondents and not only on technical measurements. Future studies should thus include both subjective and objective measures to give a more holistic picture. Finally, the study highlights the significance of taking green interior design as a link between sustainability and user well-being. The results show that there is a strong correlation between sustainable interior practices and environmental performance and positive user outcomes. The findings also indicate that environmental performance may be an important mediator for the link between green interior design and user well-being. The central message is that sustainable interior environments should not only be resource efficient, but also spaces that enable people to live in. The incorporation of environmental responsibility, indoor environmental quality, sustainable materials, resource efficiency and human-centred design can help to create a more holistic approach to sustainable interior design. This framework can be extended and expanded in the future with objective performance data, longitudinal designs, a variety of building contexts, and other behavioural and psychological variables.

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