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Article

Can Green Building Promote Pro-Environmental Behaviours? The Psychological Model and Design Strategy

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Abstract: A green building has a long lasting benefit through cultivating the occupants' energy and resource-saving behaviours. To understand how green buildings can cultivate occupants' pro-environment behaviours, the research applied the value-belief-norm model to investigate 17 pro-environmental behaviours which are related to a variety of green building design strategies. Two green and two non-green certified office buildings in the city of Shenzhen in China were surveyed, based on which structural equation modelling was established to confirm the relationship between personal values, environmental beliefs and norms that lead to pro-environment behaviours. Green and non-green building occupants showed significant differences in altruistic values, environmental awareness, personal norms, and pro-environmental behaviours. Green building users had more frequent pro-environmental behaviours than those in non-green buildings. The strategies that require fewer additional efforts were more likely to be adopted as pro-environmental behaviours, such as meeting daily needs within walking distance and adjusting sunshades, while the strategies that need extra physical efforts (taking stairs) or knowledge (garbage sorting) were less likely to be adopted as pro-environmental behaviours. This study pointed out important intervention opportunities and discussed the possible design implications for green building guidelines and programmes to cultivate green occupants and their corresponding pro-environmental behaviours.

Keywords: green buildings; green design; behavioural change; user survey; pro-environmental behaviours; value-belief-norm

1. Introduction

Over the last 30 years, the green building concept has emerged in response to the initiative of sustainable development and swept the building industry. The green building-related guidelines propose a set of environmentally friendly design, construction and operation strategies and measures that can help to reduce the energy consumption of buildings [1]. However, post-occupancy studies have shown that, to a great extent, user behaviours determine the actual energy consumption of buildings [2–4]. On the one hand, building scientists have started to understand the probability and patterns of user's behaviours in order to increase the accuracy of energy modelling at the design stage [5–7]; on the other hand, psychologists have started to understand the internal personal factors that drive the energy- and resource-saving behaviours in order to propose design strategies and programmes for effective intervention [8,9]. The former is helping green buildings meet the urgent need

of more energy-efficient building design solutions and the latter is shaping building users to anticipate a long-term green effect. This research belongs to the latter. In particular, this research aims to validate the current psychological model about pro-environmental behaviours in the context of green buildings and to determine the effective design strategies that encourage pro-environmental behaviours.

Increasingly, research has begun to explore the promotion of green buildings and their design strategies on user behaviours. For example, Azizi et al. [10] studied the green building design strategy and users' behaviours in Malaysia. The results showed that the design and management measures adopted for green buildings, such as "posting garbage sorting signs", "setting building energy consumption measurement boards in places where users often pass by", and "sending energy conservation information to users regularly", can encourage green building users to adopt more energy conservation and pro-environmental behaviours. Khashe et al. [11] used immersive environmental equipment, popularly known as virtual reality, to conduct group tests for 100 people chosen randomly, on the premise of providing the same indoor physical environment conditions with one group being informed that the building was LEED (Leadership in Energy and Environmental Design) certified (green buildings) while the other group was not informed. The results showed that users who were aware of using the green building preferred to choose more pro-environmental behaviours such as natural lighting and consciously recycling waste, indicating that the brand effect of a green building can encourage users' pro-environmental behaviours. Azizi et al. [12] conducted a questionnaire survey for teaching building users and property managers in New Zealand. The study showed that compared with traditional building users, the users in LEED-certified office buildings were more willing to sacrifice their comfort and adopt more energy conservation and pro-environmental behaviours. For the research on green building and pro-environmental behaviours, Xie et al. [13] investigated seven green buildings and 412 green building users and found that the spill-over effect caused by the energy conservation and pro-environmental behaviours of the users in green buildings promoted the purchasing intentions of consumers of green products. Noticeably, there are some studies that showed that the green building might not foster green behaviours. For example, through in-depth interviews and the use of behavioural research among 37 users of ecological housing in the UK, Gill et al. concluded that while many energy conservation design strategies have been applied in ecological housing, some users do not have good pro-environmental behaviour habits, resulting in discrepancy between the actual energy consumption and the design [14].

The role of green buildings and their design strategies in cultivating users' energy-saving behaviours is still going on and needs more studies exploring the psychological process. Previous studies tried to validate whether the green context (either specific design strategies or the general brand effect of green certification) could help to foster pro-environmental behaviours, while the internal psychological path of the formation of the pro-environmental behaviours in relation to the green context is missing. As a matter of fact, environmental psychologists have explored the internal psychological paths of pro-environmental behaviours, established pro-environmental behavioural models such as "value-belief-norm" proposed by Stern, Dietz [15] and elaborated on the promotion effect of these models on green travel, green product purchasing and other behaviours [16,17]. These studies not only revealed the psychological motivation of pro-environmental behaviours, but also provide guidance for positive intervention to cultivate pro-environmental behaviours among users.

Based on the "value-belief-norm" theory in the pro-environmental behaviour science field, the present study attempts to explore the impact of green buildings on their users' awareness and pro-environmental behaviour and the inductive role of green design strategies in user behaviours in office buildings in China. At present, China's green buildings are developing rapidly. There are nearly 5000 building projects with the Green Building Design Certification [18]. Most research on China's green buildings focuses on the assessment of design strategies and the investigation of environmental comfort [19,20] while few in-depth studies are conducted to explore the correlation between green buildings and energy conservation and pro-environmental behaviours. This paper focuses on the research on the motivation path of green building and non-green building users as well

as the causes of pro-environmental behaviours in order to reveal the potential social value of green building development.

This research takes an interdisciplinary approach of environmental psychology and architectural design to understand the green building users' awareness of environmental sustainability and their pro-environmental behaviours in relation to green design strategies. Although a green building is featured by sustainable design strategies, the users' behaviours in relation to these strategies are yet to be understood. This study is expected to produce important evidence for educating green building users to achieve the real green outcome and to avoid green wash.

2. Methods

This study surveyed office buildings in Shenzhen. As a "green pioneer" city in the field of urban and rural housing construction, Shenzhen pays considerable attention to the construction of green buildings [21]. By 2020, the green building gross floor area of Shenzhen is expected to exceed 70 million square meters. Therefore, the city can provide sufficient cases for the study of pro-environmental behaviours in different types of office buildings and its results also have significant guidance for other cities in China. In this paper, a questionnaire survey using the "value-belief-norm" model was conducted in four office buildings (2 green office buildings and 2 non-green office buildings) in Shenzhen. The questionnaire focused on the following aspects: personal economic and sociological background, type of building, personal value, environmental beliefs, and personal norms, pro-environmental behaviours in the office and at home. A structural equation model was built based on the survey results, the causal chain of behaviours was established, and the differences in pro-environmental behaviours among users of different building types were explored.

2.1. Buildings and Related Pro-Environmental Behaviours

In this study, four office buildings in Shenzhen were investigated (the location map of the survey buildings is shown in Figure 1), including two green buildings with national standard 3-star design certification; they are the Shenzhen Jianke Building and the administrative office building of Shenzhen Southern University of Science and Technology. The Shenzhen Jianke Building is located in Futian District, Shenzhen; it was built in 2009, with a total construction area of 18,168.76 square meters, 12 floors above ground and 2 floors underground. It has 14 floors in total, is 57.9 m in height, and possesses the national standard 3-star operation certification. The administrative office building of Shenzhen Southern University of Science and Technology is located in Nanshan District, Shenzhen; it was built in 2012, with a total construction area of 10,326.94 square meters, 4 floors above ground and one basement. It has 5 floors in total, and is 19.1 m height. There are two non-green buildings involved in this study as a comparison, namely the Shenzhen Tiansha International Center office building and the Shenzhen Maikelong Building. The Shenzhen Tiansha International Center office building is located in Nanshan District, Shenzhen; it was built in 2009, with a total construction area of 190,730.71 square meters, and a total of 44 floors. The Shenzhen Maikelong Building is located in Nanshan District, Shenzhen; it was built in 2010, with a total construction area of 31,500 square meters and a total of 20 floors. The two green buildings were selected for their various green design strategies (as shown in Table 1), for example, openable windows that encourage natural ventilation, shading devices and lighting switches that focus on natural lighting, control systems that are easy to adjust for personal comfort, and stair spaces conducive to use. Reasons for choosing two non-green buildings are: on the one hand, the two non-green buildings have few or no design strategies that can promote users' environmental behaviour. For example, elevators are often used inside the buildings, and the staircase design only considers anti-fire functions, lack of aesthetics and accessibility, also it cannot promote users' stair-climbing behaviour; at the same time, the two non-green building facades mostly use large-area glass curtain walls, which are inconvenient to open; on the other hand, the two non-green buildings are office buildings, and the building completion time is similar to the completion time of the two green buildings. Therefore, the four buildings are comparable.

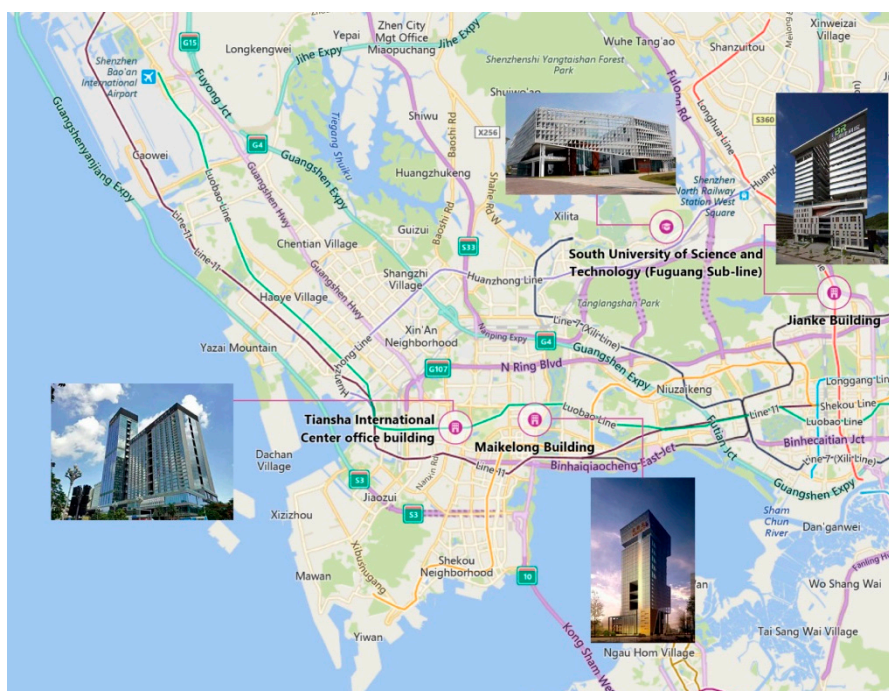


Figure 1. Location of the investigated buildings.

Based on the collation of relevant literature, this article found that some scholars have discussed the promotion of green design strategies on environmental behaviour from different perspectives in previous studies. For example, Heinen et al. found bicycle storage space, garbage sorting space, and outdoor design strategies related to functions such as space can promote users' green travel, garbage sorting and other environmental protection behaviours [11,22,23]; Zimring et al. believe that the aesthetics of staircase design can affect the frequency of users using stairs [24,25]; Khashe et al. discussed the role of self-regulating devices in green buildings to promote the energy-saving behaviour of users [11,26]; Choi et al. believed that the intelligent feedbacks provided by energy and water metering devices in the building can effectively reduce energy and water consumption in buildings [27,28]; Qian et al. are concerned about the impact of infrastructure and public transportation elements in the site on environmental protection behaviours such as green travel [29–32]; Batley et al. believe that the purchase and use of renewable resources can better guide environmental behaviours, such as promoting users to use green electricity, using reclaimed water for washing behaviour, and using electric cars to replace traditional cars for travel [33–35]; Al-Fouzan et al. emphasized the impact of parking space (including traditional car parking space and shared car parking space) on green travel behaviour [36,37]; Mahmood proposed an intelligent system to describe the concept of shared power resources within the community [38]. Based on the existing literature, this paper sorts out 7 green design categories and 17 green design strategies that can effectively guide users' environmental behaviours (see Table 2 for details). Some strategies can be found in the selected buildings and they provide a good base for the study of green building pro-environmental behaviours.

Table 1. The buildings selected for this study.

	Green Certified		Non-Green Certified	
	Shenzhen Institute of Building Research	Shenzhen Southern University of Science and Technology	Shenzhen Tiansha International Center	Shenzhen Maikelong Building
1. Commute with bicycle or use public transport	√	√	√	×
2. Garbage sorting	√	√	×	×
3. Outdoor or semi-outdoor open space	√	√	×	×
4. Stair design (excluding fireproof stairs)	√	√	×	×
5. Openable window design	√	√	√	×
6. Independent temperature control system	√	×	×	×
7. Independent lighting system	√	√	×	×
8. Adjust the shading system based on actual needs	√	√	√	√
9. Walking strategy	√	√	√	√

Table 2. Green building-related pro-environmental behaviours.

Design Category	Design Strategies	Pro-Environmental Behaviours	References
Function	Bicycle storage and shower rooms	Encourage to travel using low carbon modes of transport	Heinen and Buehle [22]
	Storage of the recyclable waste	Garbage classification	Khashe et al. [11]
	Outdoor open space	Outdoor space utilization	Huo et al. [23]
Circulation	Clearly visible stairs	Promote the use of stairs and discourage reliance on elevators	Zimring et al. [24] Ruff et al. [25]
Personal control	Individual thermal comfort control, window opening, and use of personal small fan	Energy conservation of cooling and heating	Mahdavi et al. [26]
	Locally adjustable lighting for personal lighting control	Energy conservation of artificial lighting	Khashe et al. [11]
	Adjustable sun shading	Prevent glare	Mahdavi et al. [26]
Display	Energy metering display	Pay attention to daily energy consumption and make responses	Choi et al. [27]
	Water metering and display	Water-saving behaviour	Sønderlund et al. [28]
Site	Access to community facilities and surrounding services	Meet daily living needs within walking distance	Qian et al. [29]
	Access to public transportation	Use public transportation	Cervero and Kockelman [30] Greenwald and Boarnet [31] Cervero and Murakami [32]
Renewable	Buy green power and carbon offsets	Use of energy generated from renewable sources	Batley et al. [33]
	Recycling of water resources	Use reclaimed water for flushing	Lazarova et al. [34]
	Provide electrical car parking spaces and charging piles	Buy new energy vehicles	Bakker and Trip [35]
Community and mobility	Reduce the capacity of parking spaces	Reduce car travel	Al-Fouzan [36]
	Provide shared parking Spaces	Use a shared car	Morency et al. [37]
	Sharing of public resources	Share resources with people around	Mahmood et al. [38]

2.2. The “Value–Belief–Norm” Model and Survey Instrument

According to the “value–belief–norm” model, individual pro-environmental behaviours are guided by the values and activated by specific value beliefs and personal norms. This model is used in this study to interpret the impact of personal values, environmental beliefs and personal norms of building users on energy conservation and pro-environmental behaviours. The framework (Figure 2) is composed of five parts: the first part, Part A, “values”, is about the tendency of respondents towards egoism, altruism and biosphere values; the second part is Part B, “environmental beliefs” which is referenced from the international recognized scale of new environmental paradigm (NEP); the third part, Part C, “personal norms” is about individual accountability on pro-environmental behaviours; and the fourth part, Part D and Part E “behaviours” is about the respondent’s tendency for energy conservation and pro-environmental behaviours in the use of buildings (D) and the tendency for energy conservation and pro-environmental behaviours in daily life (E).

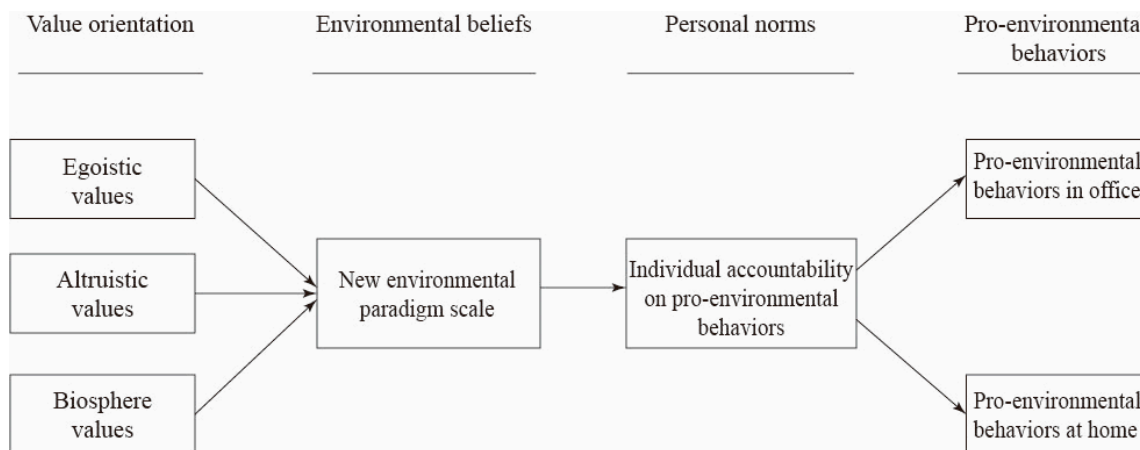


Figure 2. The “value–belief–norm” model used in this study.

The “value–belief–norm” model is captured in a standard questionnaire which usually contains five parts (A–E) and their 40 items as shown in Table 3. The present study involves five variables: values, environmental beliefs, personal norms, pro-environmental behaviours in the office and pro-environmental behaviours at home, which are measured with a 5-Point Likert Scale. On the questionnaire items on the variables of values, environmental beliefs and personal norms, the respondents were required to give a quantitative score from 1 (completely disagree) to 5 (completely agree). On the items concerning pro-environmental behaviours, the respondents were also required to rate the frequency from 1 (never) to 5 (always). The question items for values, environmental beliefs and personal norms have been used in many “value–belief–norm” studies [39–41]; the question items for pro-environmental behaviours are derived from Table 2; considering the spill-over effect [17,42], behaviours in the office and at home are included.

Table 3. Questionnaire used for measuring the “value–belief–norm” (VBN) model and pro-environment behaviours.

Variable	Measurement Questions
Part A: Value orientation	A1: Seeking benefits for others A2: Seeking equality for all A3: Focus on vulnerable groups A4: Personal power A5: Personal wealth A6: Personal social status A7: Protecting nature A8: Pollution prevention A9: Harmonious coexistence with other creatures
Part B: Environmental beliefs	B1: The total population is close to the maximum sustainable capacity of the earth B2: When humans interfere with nature, it often leads to disaster B3: Humans have seriously damaged the natural environment B4: Animals and plants should enjoy the same rights to survive as human beings B5: Human beings, despite their outstanding abilities, shall still obey the laws of nature B6: The Earth is like a spaceship with limited space and resources B7: The balance principle in nature is very fragile and vulnerable B8: If human beings continue current development, we will soon experience “ecological crisis”
Part C: Personal norms	C1: I am obliged to save energy as much as possible C2: I think that saving energy is a moral obligation, no matter what others do C3: Everyone should reduce energy consumption as much as possible C4: I feel ashamed when I waste energy C5: I am obligated to integrate environmental issues and the protection of natural resources into my daily life C6: I think energy conservation can make us better
Part D: Pro-environmental behaviours in office	D1: Commute with bicycle or use public transport D2: Garbage sorting D3: Use outdoor public space for meetings D4: Take the stairs more instead of elevators D5: Open windows during transitional seasons D6: Adjust the local air conditioning temperature based on own needs D7: Adjust the local lighting brightness based on own needs D8: Adjust the shade based on own needs D9: Solve the needs of daily life (e.g., eating and drinking) within walking distance.
Part E: Pro-environmental behaviours at home	E1: Take the stairs more instead of elevators E2: Garbage sorting E3: Check if the power is off when you leave home E4: Reduce dependence on air conditioning in summer E5: Recycling old things E6: Purchase water-saving appliances E7: Shorten the shower time E8: Remind family members to save energy

Based on the framework, the following hypotheses are made:

Hypothesis H1. *Values have a significant impact on pro-environmental behaviours and may positively drive behaviours through environmental beliefs and personal norms.*

Hypothesis H2. *There are significant differences in the values, environmental beliefs, personal norms and individual behaviours between green building users and non-green building users.*

2.3. Data Collection and Validation

This questionnaire was filled out online, and the data collection was carried out by means of peer recommendation, on-site scanning and questionnaire filling. A total of 251 completed questionnaires were collected, with 116 questionnaires from green office buildings and 135 questionnaires from non-green office buildings. The sample structure is shown in Table 4.

Table 4. Sample structure (sex/age/income/education/type of building).

Sex	Responses	Percentage	Cumulative Percentage
Male	155	61.7	61.7
Female	96	38.3	100.0
Total	251	100.0	
Age	Responses	Percentage	Cumulative Percentage
20–30	161	64.2	61.7
30–40	81	32.3	94.0
40–50	7	2.8	96.8
50 and above	2	0.7	100.0
Total	251	100.0	
Income	Responses	Percentage	Cumulative Percentage
6000 below	35	13.9	13.9
6000–10,000	69	27.5	41.4
10,000–20,000	109	43.4	84.8
20000–50,000	33	13.1	97.9
50,000 and above	5	2.1	100.0
Total	251	100.0	
Education	Responses	Percentage	Cumulative Percentage
High school	4	1.5	1.5
College	26	10.5	12
Undergraduate	147	58.6	70.6
Graduate	72	28.7	99.3
Doctor	2	0.7	100.0
Total	251	100.0	
Type of building	Responses	Percentage	Cumulative Percentage
Green building	116	46.2	46.2
Non-green building	135	53.8	100.0
Total	251	100.0	

Before the data analysis, G.Power software was used to validate whether the sample size ($N = 251$ with 116 from the green building group and 135 from the non-green building group) was sufficient to conduct the data analysis, especially the mean difference test. Based on the test family, statistical test, type of power analysis and the input of four parameters: the effect size (medium), α err prob (0.05 in general), power (0.95) and allocation ratio (1 in general), the required sample size to test the hypothesis is 105 from each group and 210 in total. Therefore, the collected sample size is acceptable to conduct the mean difference test. In addition, Cronbach's Alpha coefficient was used to analyse the reliability and validity. The analysis results show the credibility of the data (Kaiser-Meyer-Olkin, $KMO = 0.897$) is high, meets the data analysis requirements and has strong reliability.

To explore the psychological motivation for the formation of pro-environmental behaviours, structural equation modelling in SPSS and AMOS software authorized by IBM was used; the difference between green office buildings and non-green office buildings were tested using Mann–Whitney test which can compare differences between two independent groups when data are collected from the Likert scale.

3. Results

3.1. “Value–Belief–Norm” (VBN) Model for Pro-Environmental Behaviours

To understand the relationship among personal characteristics (sex/education/income), personal values (egoistic values/altruistic values/biosphere values), environmental beliefs, personal norms and individual behaviours, this study analysed the correlation, reliability and validity for these five major variables. The correlation analysis results (see Table 5) have shown that there is a correlation among all variables. The correlation between the three variables—sex, education and income—of their personal characteristics and pro-environmental behaviours is relatively insignificant, while the other five variables (egoistic values/altruistic values/biosphere values/environmental beliefs/personal norms) related to environmental protection are significantly correlated, including the most relevant pro-environmental behaviours in office and pro-environmental behaviours at home (correlation coefficient up to 0.624, and significant at the 1% level). Another significant correlation was found between the personal norms and pro-environmental behaviours at home (correlation coefficient up to 0.548, and significant at the 1% level).

Before the structural equation modelling, the fitting degree analysis and significance analysis on the data sample were carried out. Firstly, judging from the fitting indices of the model (CMIN/DF = 3267; RMSEA = 0.095; CFI = 0.794; IFI = 0.796), the model adopted in the study were fit for the structural equation modelling. The model’s overall fit index was found to be consistent with the normal standard and is reliable. Secondly, based on the significance analysis of factors and variables in the model, it was found that except for the less significant item D2: garbage sorting, all other remaining factors were significantly associated with the variables (p values were significant on both sides at the level 0.001). As a whole, at the load of 40, in addition to the aforementioned path affected by the sample conditions, analysis on other confirmatory factors showed good results. The results show that the data samples are of high quality and suitable for subsequent analysis.

On the basis of the SEM model test, it is concluded that there is a significant relationship among four major variables, namely values, environmental beliefs, personal norms, and pro-environmental behaviours. The hypothesis path of the “value–belief–norm” model being tested is basically established (see Figure 3). The data analysis has shown that (see Table 6) among the three values, altruistic values and biosphere values can promote users’ energy conservation and pro-environmental behaviours. Their effect values are: altruism—pro-environmental behaviours in the office/pro-environmental behaviours at home: 0.145/0.098; biosphere—pro-environmental behaviours in the office/pro-environmental behaviours at home: 0.279/0.236 (p values were significant on both sides at the level 0.001), among which altruistic values for “seeking benefits for others” and biosphere values for harmonious coexistence with other creatures are the most important (1.068/1.22). This shows that altruism and biosphere values have a positive and significant relationship with pro-environmental behaviours. In the relationship between egoistic values and pro-environmental behaviours, p values were respectively 0.504/0.408. Therefore, it can be found that the driving effect of egoistic values on pro-environmental behaviours is not significant. The data results have shown that environmental beliefs have a positive driving force on personal norms and pro-environmental behaviours at home, and the effect values are, respectively, 0.684/0.493 (p values were significant on both sides at the level 0.001). Due to the economic factors and work environment constraints, the environmental beliefs have no significant impact on the pro-environmental behaviours in the office. In the implementation of pro-environmental behaviours at home (without supervision and colleagues’ peer effect), the guiding effect of environmental beliefs may better reflect the pro-environmental behaviours of respondents. Data have shown that there is a significant correlation between environmental beliefs and pro-environmental behaviours at home, and the effect value is 0.493 (p values were significant on both sides at the level 0.001).

Table 5. Correlation analysis of the main variables.

	Sex	Education	Income	Green Building	Altruism	Egoism	Biosphere	Environmental Beliefs	Norms	Office Behaviours	Home Behaviours
Sex	1										
Education	−0.060	1									
Income	−0.002	−0.074	1								
Green building	−0.065	0.124	−0.095	1							
Altruism	0.123	−0.205 ***	0.015	−0.057	1						
Egoism	−0.070	0.022	−0.063	−0.083	−0.159 *	1					
Biosphere	0.039	0.013	0.061	0.035	0.206 ***	−0.463 ***	1				
Environmental beliefs	0.000	−0.020	−0.054	0.166 ***	0.164 ***	−0.177 ***	−0.098	1			
Norms	−0.082	−0.002	−0.069	0.199 ***	0.27***	−0.125 *	0.172 ***	0.494 ***	1		
Office behaviours	0.008	−0.042	0.004	0.139 *	0.455 ***	−0.333 ***	0.542 ***	0.140 *	0.5 ***	1	
Home behaviours	0.051	−0.205*	−0.039	0.172 ***	0.412 ***	−0.235 ***	0.242 ***	0.428 ***	0.548 ***	0.624 ***	1

Note: * Significant (on both sides) at the level 0.05; ** significant (on both sides) at the level 0.01; *** significant (on both sides) at the level 0.01.

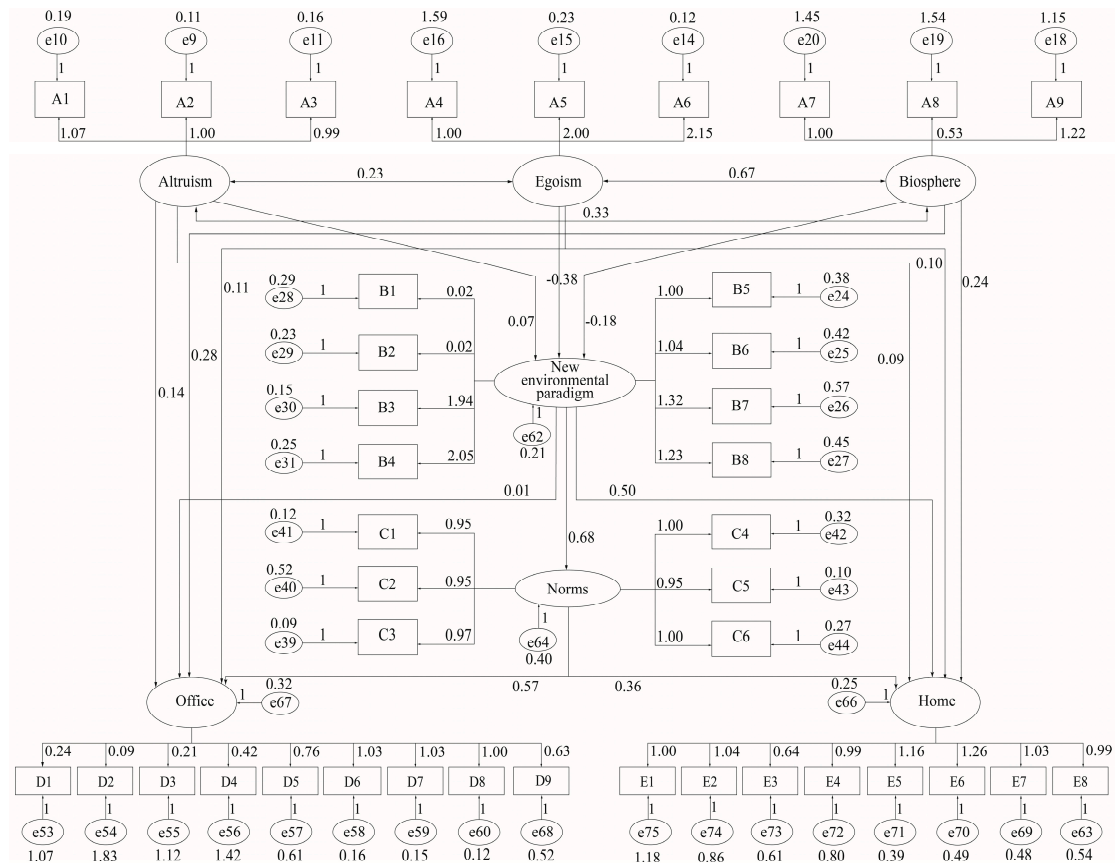


Figure 3. Structural equation model.

Table 6. Significance analysis among the variables.

Variables	Estimate	S.E.	C.R.	p	
Environmental beliefs	Altruism	0.073	0.022	3.307	***
Environmental beliefs	Egoism	-0.376	0.115	-3.258	0.001
Environmental beliefs	Biosphere	-0.179	0.072	-2.507	0.012
Norms	Environmental beliefs	0.684	0.107	6.418	***
Office behaviours	Norms	0.571	0.074	7.735	***
Home behaviours	Norms	0.36	0.074	4.848	***
Office behaviours	Altruism	0.145	0.03	4.867	***
Office behaviours	Egoism	0.095	0.142	0.668	0.504
Office behaviours	Biosphere	0.279	0.104	2.682	0.007
Home behaviours	Altruism	0.098	0.029	3.376	***
Home behaviours	Egoism	0.109	0.132	0.827	0.408
Home behaviours	Biosphere	0.236	0.098	2.401	0.016
Office behaviours	Environmental beliefs	0.012	0.109	0.106	0.916
Home behaviours	Environmental beliefs	0.493	0.119	4.137	***

Note: * Significant (on both sides) at the level 0.05; ** significant (on both sides) at the level 0.01; *** significant (on both sides) at the level 0.001.

3.2. Differences between Green and Non-Green Building Users

In the context of green and non-green buildings, the results of analysis on the differences in users' values, environmental beliefs, personal norms and pro-environmental behaviours are shown in Table 7. Through variance analysis on the samples based on the whole data set, it was found that different building contexts had significant differences in users' energy conservation and pro-environmental behaviours, environmental beliefs as well as personal norms (Sig < 0.05). Green buildings had a positive driving force for the three items above. There is a significant difference on altruistic value

(Sig < 0.05); however, no significant difference was found on the egoistic value and biosphere value (Sig > 0.05). Altruistic value, environmental beliefs, personal norms and pro-environmental behaviours are the most significant factors for the difference between green and non-green buildings. Therefore, to large extent, the hypothesis H2 is established.

Table 7. Difference analysis between green buildings and non-green buildings ($n = 251$).

		Sum of Squares	df	Mean Square	F	Sig.
Altruism	Between Groups	2.080	1	2.080	0.802	0.371
	Within Groups	646.050	249	2.595		
	Total	648.130	250			
Egoism	Between Groups	1.549	1	1.549	1.744	0.188
	Within Groups	221.249	249	0.889		
	Total	222.799	250			
Biosphere	Between Groups	0.379	1	.379	0.311	0.578
	Within Groups	303.793	249	1.220		
	Total	304.172	250			
Environmental beliefs	Between Groups	4.660	1	4.660	7.078	0.008
	Within Groups	163.927	249	0.658		
	Total	168.586	250			
Norms	Between Groups	5.240	1	5.240	10.318	0.001
	Within Groups	126.461	249	0.508		
	Total	131.701	250			
Office behaviours	Between Groups	1.669	1	1.669	4.899	0.028
	Within Groups	84.858	249	0.341		
	Total	86.527	250			
Home behaviours	Between Groups	4.683	1	4.683	7.562	0.006
	Within Groups	154.192	249	0.619		
	Total	158.875	250			

The mean values of the 17 pro-environmental behaviours in relation to the corresponding green design strategies were compared (see Table 8). The results showed that users tended to adopt pro-environmental behaviours promoted by different design strategies in green buildings and were mostly higher than those in non-green buildings, and the difference between the green buildings and non-green buildings was mostly significant ($p < 0.05$). This suggests that the sustainable design strategies in the overall green building might have stronger guiding roles in pro-environmental behaviours. In the office, users were more likely to adopt two strategies of “solving daily needs within walking distance” and “adjusting the shade based on own needs” were the highest (4.351/4.097), while the adoption of the two behaviours of “garbage sorting” and “taking the stairs” was the lowest (2.875/3.220). At home, users preferred to “check if the power is off when they leave home” and “remind family members to save energy” (4.357/3.962). Similarly, the use frequencies of the two behaviours of “garbage sorting” and “taking the stairs” were the lowest (3.285/3.420) at home.

Table 8. Comparison of the mean values of sustainable design strategies for office buildings.

		Mean Value		Standard Deviation		Significance of Difference
		Total	Total	Total	Total	
Green building	D1: Commute with bicycle or use public transport	3.630	3.650	1.009	1.054	0.739
Non-green building		3.670		1.098		
Green building	D2: Garbage sorting	3.060	2.875	1.379	1.349	0.030
Non-green building		2.690		1.318		
Green building	D3: Use outdoor public space for meetings	3.410	3.435	1.014	1.073	0.737
Non-green building		3.460		1.131		
Green building	D4: Take the stairs more instead of elevators	3.600	3.220	1.179	1.188	0.000
Non-green building		2.840		1.196		
Green building	D5: Open windows during transitional seasons	4.160	3.900	0.871	0.959	0.000
Non-green building		3.640		1.047		
Green building	D6: Adjust the local air conditioning temperature based on own needs	4.276	4.049	0.871	0.908	0.000
Non-green building		3.822		0.945		
Green building	D7: Adjust the local lighting brightness based on own needs	4.224	4.031	0.876	0.912	0.001
Non-green building		3.837		0.948		
Green building	D8: Adjust the shade based on own needs	4.319	4.097	0.798	0.858	0.000
Non-green building		3.874		0.918		
Green building	D9: Solve the needs of daily life (eating and drinking) within walking distance	4.569	4.351	0.713	0.844	0.000
Non-green building		4.133		0.976		
Green building	E1: Take the stairs more instead of elevators	3.910	3.420	1.139	1.211	0.000
Non-green building		2.930		1.282		
Green building	E2: Garbage sorting	3.700	3.285	1.040	1.123	0.000
Non-green building		2.870		1.206		
Green building	E3: Check if the power is off when you leave home	4.595	4.357	0.710	0.859	0.000
Non-green building		4.119		1.008		
Green building	E4: Reduce dependence on air conditioning in summer	4.009	3.649	1.034	1.090	0.000
Non-green building		3.289		1.145		
Green building	E5: Recycling old things	4.147	3.766	0.907	0.979	0.000
Non-green building		3.385		1.051		
Green building	E6: Purchase water-saving appliances	3.940	3.533	1.082	1.092	0.000
Non-green building		3.126		1.102		
Green building	E7: Shorten the shower time	4.000	3.697	1.004	0.987	0.000
Non-green building		3.393		0.970		
Green building	E8: Remind family members to save energy	4.345	3.962	0.856	0.948	0.000
Non-green building		3.578		1.040		

4. Discussion

Cultivating pro-environmental behaviours in buildings has practical implications to the promotion of green buildings to avoid greenwash. This study takes four office buildings (two green office buildings and two non-green office buildings) in Shenzhen as the research objects, aiming at understanding the psychological motivation and behaviour paths for generating pro-environmental behaviours in office buildings and also testifying the hypothesis as to whether the motivation and behaviours are associated with the green building context.

In this paper, a model of “value-belief-norm” with high reliability and variable correlation was established. The results showed that the users’ values, environmental beliefs, personal norms and other internal psychological motivations could effectively guide their energy conservation and pro-environmental behaviours. This indicates that environmental beliefs and personal norms have a positive impact on pro-environmental behaviours. Consequently, in the process of promoting users’ pro-environmental behaviours, it is necessary to strengthen users’ altruistic values, eco values and environmental beliefs, to let users know that pro-environmental behaviours can make them a better person. The results also showed significant difference on altruistic value, environmental beliefs, personal norms and pro-environmental behaviours between green and non-green building users. This indicates that green buildings do play a role in promoting the cultivation of individual environmental beliefs and generating pro-environmental behaviours. Noticeably, the values are affected by many factors such as personal cognition, external social environment and personal demand. Even if

the sustainable design strategies in green building can elicit users towards shaping their altruistic values, it is not enough to affect their extraverted biosphere value and introverted egoistic value.

Furthermore, this study investigated 17 pro-environment behaviours in response to a variety of green design strategies proposed. Some design strategies that were not attractive to users and required extra efforts to change were not implemented by users in the office and at home, such as taking stairs instead of lifts which involves extra physical efforts and garbage sorting which involves new knowledge while currently no relevant policies in most parts of China. The strategies of proposing fewer additional efforts were more likely to be adopted, such as meeting the daily needs within walking distance, adjusting the shade based on own needs and checking if the power is off when leaving home. For the four buildings selected by this study, their well suited locations can satisfy daily needs in walking distance; therefore, meeting daily needs within the walking distance option occurs most frequently. For the option of adjusting the sunshade based on one's own needs, the office users' visual comfort (glare) is directly affected which drives their action to adjust the shade. Family behaviours such as turning off the power in time and reminding family members to save energy are related to economic benefits while they do not require physical efforts. Therefore, the promotion effect of these strategies in users' behaviours are most significant.

In order to cultivate a pro-environmental lifestyle, the strategies with high user adoption need to be continuously promoted. The design strategies with a higher requirement for users' efforts need to be promoted through the optimization of design strategies. It was found in previous studies that the use frequency of stairs is significantly related to the aesthetic design of stairs, the lighting environment of natural lighting and the location of stairs [24,25]. Users' garbage sorting behaviour is also related to the accessibility and convenience of recycling facilities and the implementation of rewards and punitive measures [43] and is certainly related to users' internal psychological motivation–responsibility awareness [44]. Therefore, green building strategies need to strengthen publicity, improve users' pro-environmental awareness, cultivate their sense of pro-environmental responsibility, optimize sustainable design strategies, increase design aesthetic and entertainment benefits and positively guide their pro-environmental behaviours.

Although the two green buildings selected in this article have corresponding design strategies to guide pro-environmental behaviours, they still have limitations. The administrative building of Southern University of Science and Technology does not have individual temperature control devices, which makes energy-saving behaviours through adjusting temperature inapplicable. Other strategies such as open space for outdoor activities are designed to guide pro-environmental behaviour. However, in practice, it is found that, due to the excessive openness, the open space has a low usage rate in the outdoor environment with high temperature throughout the year in Shenzhen, which only has the function of circulation. Moreover, the two buildings all have garbage bins for recyclables sorting, but there is a lack of garbage sorting education and guidance near the sorting bins, which cannot help users to easily understand the procedure of garbage sorting. These findings point out that the design strategies to guide pro-environment behaviours should not be just gesture; they must be designed to consider users' habits and with the appropriate management or education programme to ensure the execution of the pro-environmental behaviours.

Currently, the research of energy conservation behaviours is more passive, looking at how to capture human's behavioural patterns and probability in an algorithm to suggest a more accurate estimation for green building standards; this research takes a more active approach suggesting that it is necessary to incorporate pro-environmental behaviours and adopt the related design strategies, rewards and punitive measures in the green building standards to provide awareness and nudge for action. Admittedly, this study also has its own limitations. Firstly, sample buildings and surveyed occupants have limitations. The size of the data sample can support the hypothesis analysis to some extent, but it still needs a larger sample size to make more generalizable conclusions. The selected buildings are varying in scale and occupancy conditions, which may also bias the results to some extent. Secondly, this paper mainly studies the differences in psychological mechanism and the use behaviour

between green building users and non-green building users, while no correlation between specific green building design strategies and energy conservation and pro-environmental behaviours is carried out to guide green building design strategies. These need to be enhanced in future studies. Thirdly, psychological factors are context specific and hard to capture. The pro-environment behaviours are based on the respondents' intention instead of real actions. Future studies shall look at how to measure the behaviours to capture the psychological factors.

5. Conclusions

The focus of this study is to discuss the psychological motivation formed from the pro-environmental behaviours in office buildings as well as the guidance and promotion of existing green building design strategies on users' pro-environmental behaviours. Based on the field investigation and data analysis for four buildings in Shenzhen, this paper holds the argument that green buildings can promote pro-environmental behaviours and can cultivate green occupants through the pro-environmental behaviours. From the analysis of results, the following conclusion can be obtained:

First, the "value-belief-norm" model established in this paper can effectively verify the psychological causes and the formation paths of pro-environment behaviours in office buildings. That is, altruistic value, biosphere value, environmental beliefs and personal norms can affect the pro-environmental behaviours of users with a correlation coefficient up to 0.624, and significant at the 1% level.

Second, in the comparison of the differences between green and non-green buildings, there is no difference between the egoistic and biosphere values ($\text{Sig} > 0.05$); the most significant difference starts from environmental beliefs ($\text{Sig} < 0.05$). It needs to be further verified that green buildings can help users to create the potential of environmental beliefs, cultivate the ability to restrain personal norms, and they can promote the formation of users' altruistic values.

Third, some design strategies that were not attractive to users and required extra efforts to change were not implemented by users in the office and at home, such as taking stairs instead of lifts which involves extra physical efforts and garbage sorting which involves new knowledge, while currently no relevant policies exist in most parts of China. The strategies of proposing fewer additional efforts were more likely to be adopted, such as meeting daily needs within walking distance, adjusting the shade based on own needs and checking if the power is off when leaving home.

To sum up, this study reveals that the role of green building in energy conservation does not only lie in technical means, but also potentially affects the users' psychological mechanisms and works on external users' pro-environmental behaviours through the design strategies of green buildings. This finding should be captured in the education of using green buildings. Most education programmes are developed for professionals to better design and manage green projects; this study addresses that users should also be well educated to use the green building to achieve the energy and resource conservation outcome.

In future studies, it is therefore suggested to increase the universality of sample data collected and explore more about the relationship between specific green building design strategies and users' energy conservation and pro-environmental behaviours to better guide green building design and promote the development of sustainable buildings. Future studies should also consider bringing the pro-environmental behaviours into the construction stage of green buildings [45–47].

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