Occupant Satisfaction in Sustainable and Conventional Higher Education Buildings

Chapter · January 2019

DOI: 10.1007/978-3-030-18652-4_8

2 authors, including:

Riza Yosia Sunindijo
UNSW Sydney
46 PUBLICATIONS **376** CITATIONS

SEE PROFILE

Published in: Szery K., Sunindijo R.Y. (2019) Occupant Satisfaction in Sustainable and Conventional Higher Education Buildings. In: Bilgin M., Danis H., Demir E., Can U. (eds) Eurasian Business Perspectives. Eurasian Studies in Business and Economics, vol 11/2. Springer, Cham, https://doi.org/10.1007/978-3-030-18652-4_8

OCCUPANT SATISFACTION IN SUSTAINABLE AND CONVENTIONAL HIGHER EDUCATION BUILDINGS

KIM SZERY
Faculty of Built Environment
UNSW Sydney
Sydney NSW 2052 Australia
ktsery@aol.com

RIZA YOSIA SUNINDIJO
Faculty of Built Environment
UNSW Sydney
Sydney NSW 2052 Australia
r.sunindijo@unsw.edu.au

Abstract: The higher education sector as a bastion of sustainability research has embarked in continual efforts to make its buildings more sustainable. Besides being environmentally friendly and economically feasible in the long run, there are perceptions that sustainable buildings are more user friendly and that their occupants are more satisfied than those in conventional buildings. However, research findings in this particular aspect of sustainability are inconclusive and even conflicting. Therefore, this research aims to study the occupant satisfaction of sustainable and conventional buildings in a higher education institution in Australia. The results show that generally there is no significant difference in occupant satisfaction between sustainable and conventional buildings. A goal of sustainable buildings to improve the wellbeing of building occupants apparently has not been achieved based on the findings of this research. There is a possibility that the development of sustainable buildings mainly focuses on the environmental aspect while the social aspect tends to be neglected. The results further show that focusing on thermal comfort is the most effective way to improve occupant satisfaction. Future developments of sustainable buildings should evolve further and find the right balance among the triple bottom line of sustainability so that they truly are sustainable buildings.

Keywords: Australia, Higher education, Occupant satisfaction, Sustainable buildings, Thermal comfort

1 Introduction

Today the development of sustainable buildings has become more and more common. Many studies have been conducted to confirm the benefits and, thus, justify the construction of such buildings. The construction industry is one of the largest users of natural resources and one of the largest contributors to environmental pollution. Sustainable development, therefore, can reduce the negative impacts of the construction industry and preserve the earth for future generations (Ortiz et al. 2009). Investments in energy efficient buildings can save current resources expended on energy, water, and waste disposal; decrease operational and maintenance costs; protect the assets against future energy price increases; and decrease greenhouse gas emissions (Eichholtz et al. 2010). Sustainable buildings also create a sense of corporate social responsibility that can increase employee attraction, retention and an organization's marketability (Heerwagen 2000). Sustainable buildings can reduce legal and

insurance costs associated with reduced risks to current and future generations especially employee health. These initiatives increase competitive advantage, improve corporate reputation, and eventually bring financial rewards to the organization (Newsham et al. 2013).

Besides being environmentally friendly and economically feasible, sustainable buildings should also be socially sustainable. One aspect of social sustainability is occupant satisfaction, health, and comfort. It is argued that sustainable buildings have an improved indoor environmental quality (IEQ) that can result in higher employee productivity due to better work and living environments (Eichholtz et al. 2010). A study suggested that improved thermal comfort and better ventilation reduce sick time and increase productivity by a modest five minutes per work day, equating to around $700 to $800 per annum per person (Kats et al. 2003). Another study argued that the indoor environment has the biggest effect on productivity in relation to job stress and job dissatisfaction so that improving the quality of the indoor environment can improve performance between 5% and 15% (Roelofsen 2002). Furthermore, due to the improvements to IEQ, building users are seen to be more satisfied with the thermal comfort of the building, design, layout and space, and ambient conditions. This satisfaction then leads to workforce attraction, retention, and greater overall occupant satisfaction (Heerwagen 2000). All this shows the importance of assessing occupant satisfaction towards their physical work environments, particularly in sustainable buildings that have become widespread today.

Higher education institutions in Australia are staunch supporters of sustainable development. Many have developed sustainable buildings and/or included them in their future campus development. However, buildings within the higher education sector do not undergo post-occupant evaluation to determine if they satisfy occupant satisfaction intended to be achieved (Baird 2010). With higher degree institutions aiming to construct more sustainable buildings, there is a need to measure occupant satisfaction of existing buildings to identify issues and fulfil the potential of these buildings. This need is becoming more important because several studies in another sector have found no direct correlations between sustainable buildings and increased occupant comfort (Paul and Taylor 2008; Rajagopalan and Thanthrige 2012). This research, therefore, aims to assess the impacts of sustainable buildings on occupant satisfaction in higher education. In order to achieve this aim, two objectives have been formulated: (1) determining factors that influence occupant satisfaction and (2) comparing occupant satisfaction in sustainable buildings with that in conventional buildings.

2 Literature Review

This literature review focuses on dimensions that are included in post-occupancy evaluation, indicating their relevance to building occupant satisfaction, wellbeing, and comfort. These dimensions are not exclusive only to higher education buildings.

2.1 Occupant tolerance

Occupant tolerance looks at the benefits associated with occupants' perceived advantages of sustainable buildings. Many international post-occupancy evaluation tools suggest that sustainable buildings better satisfy occupant comfort because occupants are more accommodating of sustainable buildings (Brager et al. 2004). Interaction between occupants and building systems and external conditions play a big role in the perceived effectiveness of these buildings (Cole et al. 2008). For example, having control over elements, such as windows, blinds, lights, and ventilators, allow a direct response to meet physical needs, factors which make occupants more tolerant of their environmental conditions, irrespective of whether conditions are actually better physically (Yang et al. 2014). In other words, if a building is able to create a sense of user control, i.e., a perceived authority over their physical environment, occupants will have better physical and emotional wellbeing. They are more satisfied if design control is made clearer to them and they understand how the building works (Leaman and

Bordass 2007). Additionally, societal views that are more pro-environmental tend to be further forgiving to their indoor environment with occupants perceiving their environmental impact is reduced in sustainable buildings, a satisfaction judgment that correlates with higher ratings of job satisfaction and wellbeing. This in turn increases productivity reduces illness symptoms, and absenteeism (Newsham et al. 2013).

2.2 Space layout

Space layout explores how a space is designed and what influences this, covering ergonomics, functionality, comfort and layout, circulation and movement, communal space and other IEQ factors. The amount of individually allocated space is one of the most significant IEQ determinants of occupant satisfaction and is a baseline expectation of occupants (Brill and Weidemann 2001; Kim and de Dear 2012). Open plan office is a key feature of sustainable building design. This, however, leads to noise complaints and loss of privacy, which cause distractions due to uncontrolled social interactions, feelings of crowding, and interruptions (De Croon et al. 2005). Despite this, occupants also say that this contemporary workspace layout and features enhance their ability to do their work due to ease of information sharing, ease of communication, increased potential for impromptu conversations, and better interactions between co-workers (Brill and Weidemann 2001; Kim and de Dear 2013).

2.3 Thermal comfort

Thermal comfort is considered as an important factor when occupants rated their workplace satisfaction (Wagner et al. 2007). Studies have shown that satisfaction related to thermal comfort in sustainable buildings is lower than that in conventional buildings. Occupants are unsatisfied with heating/cooling load distribution, air movement, access to thermostats and, lack of personal control over thermal comfort in their workspaces (Leaman and Bordass 2007; Lee and Guerin 2009). It is common for occupants to say that their work environment is too hot or too warm and that poor thermal comfort interferes with work greatly (Paul and Taylor, 2008; Wagner et al. 2007). On the other hand, there are also studies that found that occupants in sustainable buildings are more satisfied with thermal comfort than occupants in conventional buildings (Newsham et al. 2013). They are more satisfied with the reduced disturbance from heating systems, better thermal gain in winter, and less temperature variance (Newsham et al. 2013; Wagner et al. 2007).

2.4 Acoustics

Acoustics is influenced by many factors, including transmissible and ambient sounds, external sounds, office systems and machines, occupants' sounds, and design influence. Open office layout, which is common in sustainable buildings, lowers occupant satisfaction in terms of acoustics. High rates of sound transmission, loss of speech privacy, distractions due to people talking, and high background noise levels are common complaints from sustainable building occupants (Heerwagen and Zagreus 2005; Wilkinson et al. 2011). This trend can be attributed to rating systems that place no emphasis around acoustics and the propagation of noise, which are the most problematic acoustic issues in offices (Newsham et al. 2013). Rating systems, such as Leadership in Energy and Environmental Design (LEED), give priority towards design features that may negatively impact acoustic performance, such as low partitions to allow the penetration of natural light and enhance views, and hard ceilings and floors to improve air quality (Hwang and Kim 2011). Despite rating noise levels poorly, Paevere et al. (2008) argued that sustainable building occupants are still satisfied with the overall performance of their buildings.

2.5 Lighting

Lighting covers the impacts of natural and ambient lighting on occupants. Sustainable design often involves the use of natural light to reduce electricity usage. Furthermore, natural light has been acclaimed to increase sense of wellbeing, improve performance, enhance occupant's ability to work, increase productivity, and increase satisfaction (Heerwagen and Zagreus 2005). However, research has also identified lighting-related issues in sustainable buildings, where many building users complained about the low level of luminance in their workspace (Lee and Guerin 2009). Others argue that natural light becomes the source of glare and thermal gain (Abbaszadeh et al. 2006). Hwang and Kim (2011) found that inadequate provision of controls and difficulties to operate shading devices contribute to the lack of effort from occupants to adjust natural light for visual comfort. As a result, sustainable buildings show no significant improvement in occupant satisfaction in comparison to conventional buildings (Abbaszadeh et al. 2006).

2.6 Indoor air quality

With indoor air quality (IAQ) being a key aspect that boosts employee health and reduces excessive morbidity and mortality, sustainable buildings have lower levels of air pollutants that conventional ones (Newsham et al. 2013). Perceived poor air quality in conventional buildings increases sick building syndrome and adversely affects occupant performance (Lee and Guerin 2009). On the contrary, IAQ in sustainable buildings increases performance and reduces absenteeism. This can be attributed to reductions in airborne contaminants, natural ventilation, and the use of low-toxicity finishes and furnishings (Paul and Taylor 2008). Due to sustainable design space layout and air quality that mimics outside environments, mental well-being and self-reported health are also increased (Hwang and Kim 2011).

2.7 Visual comfort

Visual comfort measures the effects of the visual and mental representation of sustainable buildings on occupant satisfaction. Sustainable buildings can increase the marketability of the organization, particularly since pro-environmental consumers are increasing in number (Edwards 2006). Around 97% of survey respondents said they were honored to show their office to visitors (Abbaszadeh et al. 2006). Access to green space also improves the aesthetic value of the building and makes building occupants believe that sustainable buildings have positive impacts on health and productivity (Armitage et al. 2011). All this creates an IEQ that provides a more aesthetically and physically pleasing environment, thus increasing occupant satisfaction and bringing other economic and social benefits (Paul and Taylor 2008). It should be noted, however, that sustainable materials may increase surface reflection and glare (Armitage et al. 2011).

3 Research Method

An online questionnaire was used to collect the occupants' perceived levels of satisfaction towards their workspace in a higher degree institution in Australia. The questionnaire has three sections. The first section captured the profile of the respondent, including age, gender, employment status, building name within the institution (to determine whether it is a sustainable or conventional building), and work area and arrangement. The second section assessed the satisfaction level of the seven dimensions of IEQ, comprising space layout, thermal comfort, acoustics, lighting, IAQ and visual comfort. A five-point Likert scale ranging from "highly dissatisfied" to "highly satisfied" was used in this section. The third section asked the overall satisfaction of the respondent towards their building and the impacts of the workspace on the respondent's comfort and productivity. A five-point Likert scale ranging from strongly disagrees to strongly agree was used in this section.

The buildings selected are all used for educational purposes and contain office and research student space to establish uniformity. The survey was distributed to staff and research students

who use the selected buildings on a regular basis. The respondents were invited to participate in the survey through an email invitation letter distributed via faculty offices, which contained the instructions as well as the link to complete the online questionnaire. Data we collected within a four-week period in July and August 2017 (winter season).

4 Analysis and Discussion

A total of 106 valid responses were obtained. The response rate cannot be determined because the number of participants is not known. About 48% (N=51) of the respondents were male and 52% were female (N=55). The median age of the respondents was within the 35-39 years' age range. Twenty-five academic staff (23.6%), 39 professional staff (36.8%), and 42 research students (39.6%) participated in the survey. Furthermore, 76 respondents (71.7%) were based in sustainable buildings, while the remaining 30 (28.3%) in conventional buildings.

The following analyses focus on the satisfaction levels of the seven dimensions, the difference in satisfaction levels between sustainable and conventional buildings, and the correlations between the seven satisfaction dimensions and overall satisfaction, comfort, and productivity. Two samples t-test was used to determine the difference between the two types of buildings, while Pearson's correlation was used to determine the relationships between the satisfaction items and overall satisfaction, comfort, and productivity.

4.1 Space layout

In overall, the respondents were satisfied with the space layout dimension as shown in Table 1. There was a concern with the level of visual privacy perhaps because the majority of the respondents indicated that they worked in an open plan office with low partitions. There is no significant difference in terms of satisfaction level between sustainable and conventional buildings.

Table 1 Satisfaction towards space layout

Item	Overall	Sustainable buildings	Conventional buildings	Significance difference
The amount of space available to you at your normal work area	4.01	4.12	3.73	0.09
The amount of storage space available to you	3.75	3.79	3.67	0.60
The quality of overall personal work space	3.82	3.91	3.60	0.16
The level of visual privacy (not being seen by others)	3.21	3.33	2.90	0.08
Ease of interactions with co-workers	3.84	3.83	3.87	0.85
Office layout for circulation and movement	3.48	3.46	3.53	0.73

Note: 1 = highly dissatisfied; 2 = dissatisfied; 3 = neutral; 4 = satisfied; 5 = highly satisfied

Table 2 shows the Pearson's correlations between the space layout satisfaction items and overall satisfaction, comfort, and productivity. This result shows that higher degree institutions should focus on the quality of overall personal workspace and the amount of space if they want to increase the satisfaction, comfort, and productivity of their people. The level of visual privacy, the least satisfied item, is the least important space layout factor that influences the three outcomes.

Table 2 Correlation between space layout and overall satisfaction and productivity

Item		Overall satisfaction	Productivity	Overall comfort
The amount of space available to you at your normal work area	Correlation	.419**	.336**	.447**
	Sig. (2-tailed)	0.000	0.000	0.000
The amount of storage space available to you	Correlation	.330**	.267**	.422**
	Sig. (2-tailed)	0.001	0.006	0.000
The quality of overall personal work space	Correlation	.506**	.529**	.557**
	Sig. (2-tailed)	0.000	0.000	0.000
The level of visual privacy (not being seen by others)	Correlation	.201*	0.183	.293**
	Sig. (2-tailed)	0.039	0.060	0.002
Ease of interactions with co-workers	Correlation	.237*	.255**	.231*
	Sig. (2-tailed)	0.015	0.008	0.017
Office layout in regard to circulation and movement	Correlation	.342**	.325**	.406**
	Sig. (2-tailed)	0.000	0.001	0.000

Note: **. Correlation is significant at equal to or less than 0.01 level (2-tailed).
*. Correlation is significant at equal to or less than 0.05 level (2-tailed).

4.2 Thermal comfort

Table 3 shows that the respondents were neither satisfied nor dissatisfied when it comes to the thermal comfort of their workspace. It should be noted that this dimension has the lowest satisfaction level among the seven dimensions included in this research. Likewise, Lee and Guerin (2009) found that this dimension is also one of the lowest in their research. Personal control over the temperature of the work area is the lowest satisfaction item in this research. It also seems that the office spaces do not respond well to changes in temperature. There is no significant difference in the satisfaction levels between sustainable and conventional buildings in terms of thermal comfort.

Table 3 Satisfaction towards thermal comfort

Item	Overall	Sustainable buildings	Conventional buildings	Significance difference
The temperature of your normal work area in summer	2.78	2.74	2.90	0.54
The temperature of your normal work area in winter	2.95	2.89	3.10	0.42
The ability to get the work done in relation to quality of thermal comfort	3.14	3.13	3.17	0.89
Personal control over the temperature of your normal work area	2.54	2.54	2.53	0.98
Your office's ability to respond to changes in temperature	2.64	2.67	2.57	0.69

Note: 1 = highly dissatisfied; 2 = dissatisfied; 3 = neutral; 4 = satisfied; 5 = highly satisfied

As shown in Table 4, all thermal comfort items are strongly correlated with overall satisfaction, productivity, and overall comfort. High education institutions should focus on improving this dimension in the design stage. The ability of office space to respond to changes in temperature adequately and personal control over the temperature of the work space seem to be the key to address the issues related to this dimension.

Table 4 Correlation between thermal comfort and overall satisfaction and productivity

Item		Overall satisfaction	Productivity	Overall comfort
The temperature of your normal work area in summer	Correlation	.452**	.379**	.441**
	Sig. (2-tailed)	0.000	0.000	0.000
The temperature of your normal work area in winter	Correlation	.492**	.382**	.493**
	Sig. (2-tailed)	0.000	0.000	0.000
The ability to get the work done in relation to quality of thermal comfort	Correlation	.529**	.420**	.502**
	Sig. (2-tailed)	0.000	0.000	0.000
Personal control over the temperature of your normal work area	Correlation	.465**	.424**	.539**
	Sig. (2-tailed)	0.000	0.000	0.000
Your office's ability to respond to changes in temperature	Correlation	.461**	.393**	.515**
	Sig. (2-tailed)	0.000	0.000	0.000

Note: **. Correlation is significant at equal to or less than 0.01 level (2-tailed). *. Correlation is significant at equal to or less than 0.05 level (2-tailed).

4.3 Acoustics

As shown in Table 5, sound privacy is the most serious issue in this dimension. Newsham et al. (2013) indicated that low satisfaction is caused by excessive propagation of speech noise. The tendency of using open office layout today seems to be the source of this issue. Like the other previous dimensions, there is also no significant difference in terms of acoustics performance between sustainable and conventional buildings.

Table 5 Satisfaction towards acoustics

Item	Overall	Sustainable buildings	Conventional buildings	Significance difference
The overall noise level in your personal work space	3.24	3.14	3.47	0.18
The sound privacy in your personal work space	2.57	2.54	2.63	0.70
The ability to get work done in relation to the quality of acoustics	3.32	3.30	3.37	0.78
Noise from office equipment	3.55	3.54	3.57	0.90
Noise from external outdoor traffic	3.69	3.59	3.93	0.12
Noise from people talking	2.91	2.83	3.10	0.24

Note: 1 = highly dissatisfied; 2 = dissatisfied; 3 = neutral; 4 = satisfied; 5 = highly satisfied

The correlations in Table 6 indicate that improving sound privacy is the best way to improve overall satisfaction, comfort, and productivity in the acoustics dimension.

Table 6 Correlation between acoustics performance and overall satisfaction and productivity

Item		Overall satisfaction	Productivity	Overall comfort
The overall noise level in your personal work space	Correlation	.285**	.299**	.292**
	Sig. (2-tailed)	0.003	0.002	0.002
The sound privacy in your personal work space	Correlation	.359**	.216*	.389**
	Sig. (2-tailed)	0.000	0.026	0.000
The ability to get work done in relation to the quality of acoustics	Correlation	.302**	.334**	.285**
	Sig. (2-tailed)	0.002	0.000	0.003
Noise from office equipment	Correlation	.250**	.242*	.223*
	Sig. (2-tailed)	0.010	0.012	0.021
Noise from external outdoor traffic	Correlation	0.085	-0.005	0.012
	Sig. (2-tailed)	0.384	0.962	0.899
Noise from people talking	Correlation	.318**	.325**	.330**
	Sig. (2-tailed)	0.001	0.001	0.001

Note: **. Correlation is significant at equal to or less than 0.01 level (2-tailed). *. Correlation is significant at equal to or less than 0.05 level (2-tailed).

4.4 Lighting

Table 7 shows that the respondents were generally satisfied with the lighting in their workspace. Respondents in sustainable buildings were more satisfied with the amount of natural light than those in conventional buildings. This is understandable because natural lighting is always one of the most important factors in any sustainability rating tool.

Table 7 Satisfaction towards lighting

Item	Overall	Sustainable buildings	Conventional buildings	Significance difference
The amount of natural light in your personal work space	3.51	**3.78**	**2.83**	**0.00**
The amount of artificial light in your personal work space	3.78	3.89	3.50	0.07
The visual comfort of the lighting (glare, reflections, contrast, etc.)	3.59	3.62	3.53	0.71
The ability to get work done in relation to the quality of lighting	3.86	3.93	3.67	0.15
The ability to control the level of natural lighting and unwanted glare in your personal work space	3.55	3.64	3.30	0.12

Note: 1 = highly dissatisfied; 2 = dissatisfied; 3 = neutral; 4 = satisfied; 5 = highly satisfied
Bold indicates that the difference is significant at 0.05 level

Table 8 shows that the lighting satisfaction items have strong correlations with overall satisfaction, comfort, and productivity. The correlations also indicate that the amount of natural light is not as important as artificial lighting and visual comfort when it comes to the three outcomes. As such, providing sufficient amount of light, either artificial or natural, is the easiest way to reap the benefits of this particular dimension.

Table 8 Correlation between lighting and overall satisfaction and productivity

Item		Overall satisfaction	Productivity	Overall comfort
The amount of natural light in your personal work space	Correlation	.287**	.238*	.320**
	Sig. (2-tailed)	0.003	0.014	0.001
The amount of artificial light in your personal work space	Correlation	.429**	.409**	.342**
	Sig. (2-tailed)	0.000	0.000	0.000
The visual comfort of the lighting (glare, reflections, contrast, etc.)	Correlation	.423**	.396**	.376**
	Sig. (2-tailed)	0.000	0.000	0.000
The ability to get work done in relation to the quality of lighting	Correlation	.439**	.424**	.398**
	Sig. (2-tailed)	0.000	0.000	0.000
The ability to control the level of natural lighting and unwanted glare in your personal work space	Correlation	.380**	.351**	.337**
	Sig. (2-tailed)	0.000	0.000	0.000

**. Correlation is significant at equal to or less than 0.01 level (2-tailed).
*. Correlation is significant at equal to or less than 0.05 level (2-tailed).

4.5 Indoor air quality

As shown in Table 9, the levels of satisfaction for this dimension are around the neutral and satisfied ratings. The least satisfied item is related to the access to windows to control air flow. The level of satisfaction for this item is also lower in sustainable buildings than that in conventional ones. The open plan office and the lack of operable windows in newer buildings may be the reason for this.

Table 9 Satisfaction towards indoor air quality

Item	Overall	Sustainable buildings	Conventional buildings	Significance difference
The quality of air in your personal work space (stuffy/stale air, cleanliness, odors, etc.)	3.46	3.37	3.50	0.51
Ventilation/air movement	3.35	3.43	3.32	0.59
The overall humidity in your normal work area	3.55	3.37	3.62	0.18
The ability to get work done in relation to indoor air quality	3.62	3.47	3.68	0.23
Windows in terms of control over the level of natural air flow in your office or personal work space	2.90	**2.50**	**3.05**	**0.02**

Note: 1 = highly dissatisfied; 2 = dissatisfied; 3 = neutral; 4 = satisfied; 5 = highly satisfied
Bold indicates that the difference is significant at 0.05 level

Even though the control of windows is the least satisfied item, as shown in Table 10, the influence of this item on overall satisfaction, comfort, and productivity is also the least within this dimension. Improving these three outcomes can be achieved better by improving air quality, ventilation, and humidity. Ironically, one way to improve this IAQ is actually by providing access to windows.

Table 10 Correlation between indoor air quality and overall satisfaction and productivity

Item		Overall satisfaction	Productivity	Overall comfort
The quality of air in your personal work space (stuffy/stale air, cleanliness, odors, etc.)	Correlation	.529**	.459**	.453**
	Sig. (2-tailed)	0.000	0.000	0.000
Ventilation/air movement	Correlation	.507**	.439**	.443**
	Sig. (2-tailed)	0.000	0.000	0.000
The overall humidity in your normal work area	Correlation	.469**	.314**	.419**
	Sig. (2-tailed)	0.000	0.001	0.000
The ability to get work done in relation to indoor air quality	Correlation	.500**	.385**	.474**
	Sig. (2-tailed)	0.000	0.000	0.000
Windows in terms of control over the level of natural air flow in your office or personal work space	Correlation	.313**	.262**	.328**
	Sig. (2-tailed)	0.001	0.007	0.001

Note: **. Correlation is significant at equal to or less than 0.01 level (2-tailed). *. Correlation is significant at equal to or less than 0.05 level (2-tailed).

4.6 Visual comfort

Table 11 shows that the respondents were relatively satisfied with all the items in the visual comfort dimension. The respondents in sustainable buildings were more satisfied than those in conventional buildings in terms of furniture and surface finishes, and the overall aesthetic of the building.

Table 11 Satisfaction towards visual comfort

Item	Overall	Sustainable buildings	Conventional buildings	Significance difference
The colors and textures of flooring, furniture and surface finishes	3.58	**3.70**	**3.30**	**0.03**
Glare from surfaces in your office area	3.66	3.70	3.57	0.42
Access to indoor or outdoor green space for breaks and recreation	3.36	3.33	3.43	0.67
The overall aesthetics of the building	3.33	**3.51**	**2.87**	**0.00**
The external view from your normal work area	3.26	3.38	2.97	0.14

Note: 1 = highly dissatisfied; 2 = dissatisfied; 3 = neutral; 4 = satisfied; 5 = highly satisfied
Bold indicates that the difference is significant at 0.05 level

The correlations in Table 12 show that improving overall satisfaction, comfort, and productivity can be best achieved by improving the overall building aesthetic and improving the external view from the workspace area. It is good to see, therefore, that newer, sustainable buildings have better overall aesthetic than conventional buildings because this item influences the three outcomes strongly.

Table 12 Correlation between visual comfort and overall satisfaction and productivity

Item		Overall satisfaction	Productivity	Overall comfort
The colors and textures of flooring, furniture and surface finishes	Correlation	.351**	.371**	.351**
	Sig. (2-tailed)	0.000	0.000	0.000
Glare from surfaces in your office area	Correlation	.204*	.226*	.234*
	Sig. (2-tailed)	0.036	0.020	0.016
Access to indoor or outdoor green space for breaks and recreation	Correlation	.357**	.330**	.391**
	Sig. (2-tailed)	0.000	0.001	0.000
The overall aesthetics of the building	Correlation	.433**	.406**	.405**
	Sig. (2-tailed)	0.000	0.000	0.000
The external view from your normal work area	Correlation	.422**	.407**	.452**
	Sig. (2-tailed)	0.000	0.000	0.000

Note: **. Correlation is significant at equal to or less than 0.01 level (2-tailed). *. Correlation is significant at equal to or less than 0.05 level (2-tailed).

4.7 Additional discussion

Table 13 summarizes the results by ranking the 10 lowest satisfaction items and their influence on overall satisfaction, comfort, and productivity. The correlations above 0.400 are presented in bold. This table clearly shows that higher education institutions should focus on thermal comfort if they want to improve the overall satisfaction, comfort, and productivity of their people. Higher education buildings should be able to adapt better to changes in temperature and should have acceptable temperatures in summer and winter. A personal control over the temperature in the workspace should also be considered, although this is hard to be implemented due to the open office plan commonly integrated into sustainable buildings today.

Table 13 Lowest satisfaction items

Item	Satisfaction level	Correlation		
		Overall satisfaction	Productivity	Overall comfort
Personal control over the temperature of your normal work area	2.54	**.465****	**.424****	**.539****
The sound privacy in your personal work space	2.57	.359**	.216*	.389**
Your office's ability to respond to changes in temperature	2.64	**.461****	.393**	**.515****
The temperature of your normal work area in summer	2.78	**.452****	.379**	**.441****
Windows in terms of control over the level of natural air flow in your office or personal work space	2.9	.313**	.262**	.328**
Noise from people talking	2.91	.318**	.325**	.330**
The temperature of your normal work area in winter	2.95	**.492****	.382**	**.493****
The ability to get the work done in relation to quality of thermal comfort	3.14	**.529****	**.420****	**.502****
The level of visual privacy (not being seen by others)	3.21	.201*	0.183	.293**
The overall noise level in your personal work space	3.24	.285**	.299**	.292**

5 Conclusion

This research aims to investigate the levels of occupant satisfaction in sustainable and conventional buildings in higher education. Sustainable buildings are supposed to integrate economic, social, and environmental aspects of sustainability. One social aspect of sustainability is related to occupant satisfaction, health, wellbeing, and comfort. Many suggest that sustainable buildings are superior than conventional buildings on this particular aspect. As such, sustainable building occupants should be satisfied with their workspace, which can also increase their productivity and bring other benefits for the organization. This hypothesis has been tested in this research in the context of higher education.

The research began with identifying six sustainability-related dimensions that can influence occupant satisfaction. The six dimensions are space layout, thermal comfort, acoustics, lighting, indoor air quality, and visual comfort. The results show that, within these seven dimensions, generally there is no significant difference in the levels of occupant satisfaction between sustainable and conventional buildings. As such, sustainable buildings in higher education do not deliver one of the social aspects expected from them. It is possible that the development of sustainable buildings mainly focuses on the environmental aspect due to a number of reasons while the social aspect tends to be neglected. It is, however, reassuring to find out that at least sustainable buildings do not perform worse than conventional buildings.

Correlation analysis was performed to determine the relationships between the satisfaction items within the seven dimensions and overall satisfaction, comfort, and productivity. From this analysis, the items that have relatively low satisfaction level, but strong influence on the three outcomes were identified. The result shows that, if higher education institutions intend to improve their occupants' overall satisfaction, comfort, and productivity, they should focus on thermal comfort. It is important for the workspace to be comfortable in summer and winter, for occupants to have personal control over the temperature, and for the building to be able to adapt adequately to changes in temperature.

There are several limitations of this research worth mentioning. First, data were collected from one higher education institution in Australia, so the results may not be applicable nationwide or internationally. More data are required to get a more comprehensive view. Second, data that represent conventional buildings are fairly limited in this research. More data are needed to test the validity of the results.

References

Abbaszadeh, S., Zagreus, L., Lehrer, D., and Huizenga, C., 2006. Occupant satisfaction with indoor environmental quality in green buildings. In: de Oliveira Fernandes, E., Gameiro da Silva, M., and Rosado Pinto, J. (Eds.), *8th International Conference and Exhibition on Healthy Buildings*. Lisboa, Portugal, 4-8 June 2006. Herndon, VA: International Society of Indoor Air Quality and Climate.

Armitage, L., Murugan, A., and Kato, H., 2011. Green offices in Australia: A user perception survey. *Journal of Corporate Real Estate*, 13(3), pp.169-180.

Baird, G., 2010. *Sustainable buildings in practice: What the users think*. Oxon, UK: Routledge.

Brager, G., Paliaga, G., and De Dear, R., 2004. Operable windows, personal control and occupant comfort. *ASHRAE Transactions*, 110(Part 2), pp.17-35.

Brill, M. and Weidemann, S., 2001. *Disproving widespread myths about workplace design*. Buffalo, NY: Kimball International.

Cole, R. J., Robinson, J., Brown, Z., and O'shea, M., 2008. Re-contextualizing the notion of comfort. *Building Research & Information*, 36(4), pp.323-336.

De Croon, E., Sluiter, J., Kuijer, P. P., and Frings-Dresen, M., 2005. The effect of office concepts on worker health and performance: A systematic review of the literature. *Ergonomics*, 48(2), pp.119-134.

Edwards, B., 2006. Benefits of green offices in the UK: Analysis from examples built in the 1990s. *Sustainable Development*, 14(3), pp.190-204.

Eichholtz, P., Kok, N., and Quigley, J. M., 2010. Doing well by doing good? Green office buildings. *The American Economic Review*, 100(5), pp.2492-2509.

Heerwagen, J., 2000. Green buildings, organizational success and occupant productivity. *Building Research & Information*, 28(5-6), pp.353-367.

Heerwagen, J. and Zagreus, L., 2005. *The human factors of sustainable building design: Post occupancy evaluation of the Philip Merrill Environmental Center, Annapolis, MD*. Berkeley, CA: The Center for the Built Environment.

Hwang, T. and Kim, J. T., 2011. Effects of indoor lighting on occupants' visual comfort and eye health in a green building. *Indoor and Built Environment*, 20(1), pp.75-90.

Kats, G., Alevantis, L., Berman, A., Mills, E., and Perlman, J., 2003. *The costs and financial benefits of green buildings: A report to California's sustainable building task force*. Sacramento, CA: California Department of Resources Recycling and Recovery.

Kim, J. and de Dear, R., 2012. Nonlinear relationships between individual IEQ factors and overall workspace satisfaction. *Building and Environment*, 49, pp. 33-40.

Kim, J. and de Dear, R., 2013. Workspace satisfaction: The privacy-communication trade-off in open-plan offices. *Journal of Environmental Psychology*, 36, pp.18-26.

Leaman, A. and Bordass, B., 2001. Assessing building performance in use 4: The Probe occupant surveys and their implications. *Building Research & Information*, 29(2), pp.129-143.

Lee, Y. S. and Guerin, D. A., 2009. Indoor environmental quality related to occupant satisfaction and performance in LEED-certified buildings. *Indoor and Built Environment*, 18(4), pp.293-300.

Newsham, G. R., Birt, B. J., Arsenault, C., Thompson, A. J. L., Veitch, J. A., Mancini, S., Galasiu, A. D., Gover, B. N., Macdonald, I. A., and Burns, G. J., 2013. Do 'green' buildings have better indoor environments? New evidence. *Building Research & Information*, 41(4), pp.415-434.

Ortiz, O., Castells, F., and Sonnemann, G., 2009. Sustainability in the construction industry: A review of recent developments based on LCA. *Construction and Building Materials*, 23(1), pp.28-39.

Paevere, P., Brown, S., Leaman, A., Luther, M., and Adams, R., 2008. Indoor environment quality and occupant productivity in the CH2 building. In: Foliente, G., Luetzkendorf, T., Newton, P., and Paevere, P. (Eds.), *2008 International Scientific Committee World Sustainable Building Conference*. Melbourne, Australia, 21-25 September 2008. Balnarring, Australia: ASN Events Pty.

Paul, W. L. and Taylor, P. A., 2008. A comparison of occupant comfort and satisfaction between a green building and a conventional building. *Building and Environment*, 43(11), pp.1858-1870.

Rajagopalan, P. and Thanthrige, V., 2012. Occupant satisfaction of Star Rated Houses in Victoria, Australia. In: *Proceedings of the 10th International Conference of Healthy Buildings*. Brisbane, Australia, 8-12 July 2012. Herndon, VA: International Society of Indoor Air Quality and Climate.

Roelofsen, P., 2002. The impact of office environments on employee performance: The design of the workplace as a strategy for productivity enhancement. *Journal of Facilities Management*, 1(3), pp.247-264.

Wagner, A., Gossauer, E., Moosmann, C., Gropp, T., and Leonhart, R., 2007. Thermal comfort and workplace occupant satisfaction—Results of field studies in German low energy office buildings. *Energy and Buildings*, 39(7), pp.758-769.

Wilkinson, S. J., Reed, R., and Jailani, J., 2011. User satisfaction in sustainable office buildings: a preliminary study. In: *Proceedings of the 17th Pacific Rim Real Estate Society Annual Conference*, Gold Coast, Australia, 16-19 January 2011. Sydney, Australia: Pacific Rim Real Estate Society.

Yang, L., Yan, H., and Lam, J. C., 2014. Thermal comfort and building energy consumption implications–A review. *Applied Energy*, 115, pp.164-173.