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A comparison of occupant comfort and satisfaction between a green building and a conventional building

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Abstract

It has been argued that "green" buildings have a better indoor environmental quality (as measured by the comfort perceptions of occupants) than conventional buildings and that this translates into a more satisfying workplace for the building's occupants and, in turn, a more productive workforce. To test this we measured the comfort and satisfaction perceptions of the occupants of a green university building and two conventional university buildings with a questionnaire that asked occupants to rate their workplace environment in terms of aesthetics, serenity, lighting, acoustics, ventilation, temperature, humidity, and overall satisfaction. The university buildings at the centre of the study are located in Albury-Wodonga, in inland southeast Australia. The green building, which is naturally ventilated, is constructed from rammed earth and recycled materials. The conventional buildings have heating, ventilating, and air-conditioning (HVAC) systems and are of brick veneer construction. We found no evidence to believe that green buildings are more comfortable. Indeed, the only difference between the buildings was that occupants of the green building were more likely to perceive their work environment as warm, and occupants who felt warm were more likely to describe their work environment as poor. However, the hydronic cooling system of this building was malfunctioning at the time of the study and hence this result cannot be generalised as a difference between *green* buildings and *conventional* HVAC buildings. All other aspects of comfort, including aesthetics, serenity, lighting, ventilation, acoustics, and humidity, were not perceived differently by the occupants of the two types of building.

Keywords: Comfort; Satisfaction; Green building; Causal model

1. Introduction

In Australia there is a small but growing movement towards the design and construction of "green" buildings [1]. To ensure continued growth in the adoption of green building technologies it is important to ensure that customer needs are being addressed and that claims of performance are warranted; this means evaluating the performance and life-cycle costs of new green buildings as they come on line. Of particular import to corporate customers is the indoor environmental quality (usually measured in terms of occupant comfort) of a building because there is evidence that links comfort to satisfaction and productivity [2]. Heerwagen and Zagreus [3], however, note that while it is widely believed that green buildings are more comfortable than conventional buildings, thereby making them more satisfying and productive workplaces, there is little empirical evidence to support this belief.

In order for the work environment of green buildings to be more comfortable and satisfying than conventional buildings there must be some features that are unique, or at least more common, to their design that could contribute to a better indoor environmental quality. Furthermore, there must be a link between comfort and satisfaction.

Some of the features that relate to the indoor environmental quality of a building would include natural ventilation and the use of low-toxicity finishes and furnishings (resulting in better air quality), natural lighting for a better quality of illumination, operable windows and fans that enable personal control over ambient conditions and access to outdoor sounds, and recycled materials that could be considered to provide a more serene and aesthetically pleasing interior. All of these are standard

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design features (or options) for green buildings [4], and we believe it is reasonable to say that these features are more common to green buildings than conventional buildings. It is not clear, however, that such features lead to a better indoor environmental quality.

Browning and Romm [5] report on various pre–post observational studies that examined the effect of energy-efficient designs on worker productivity. One study involved an energy-efficient retrofit to the Main Post Office in Reno, Nevada. A new ceiling was fitted to the building to improve the lighting, temperature, and noise within the mail sorting room. Productivity is reported to have increased by 6–8% after the retrofit. As with any single-group pre–post study of this kind, however, one needs to be careful to rule out other reasons for the observed increase. Browning and Romm argue that there was no coincidental plan to improve productivity at the time of the retrofit and that productivity had always been measured. Unfortunately, the graph they presented shows only the increase in productivity following the retrofit. If productivity was measured as part of normal operations it would have been informative to show the productivity data for the pre-retrofit period as well. They also imply that productivity gains at the Reno office were more than that experienced by other sorters in the western region of the United States. The data for these other offices, however, were not presented. Thus, the evidence for a link between energy-efficient design and productivity from this study is not particularly strong. Furthermore, the retrofit addressed lighting, temperature, and sound, so it is not possible to attribute the reported productivity increase to a particular change, only to the retrofit in general.

Similarly, the second example cited by Browning and Romm, concerning the Nederlandshe Middenstandbank, involved many changes to the design of the new building—some of which could not be claimed as unique to green buildings, such as the S-curve ground plan with gardens, courtyards, restaurants, and meeting rooms. Accordingly, it is not possible to attribute the reported 15% decrease in absenteeism to the green features of the new building, which included daylighting and natural ventilation through operable windows.

The third example cited by Browning and Romm is a Wal-Mart store that installed skylights in only one-half of the store. It was reported that sales (per square foot) were much higher for those departments located in the day-lit half, but there could be many reasons why sales differed between the two groups of departments.

Heerwagen [2] reviewed the literature on green buildings and occupant productivity. One of the studies cited was the aforementioned research by Browning and Romm [5]. Another was that by Leaman [6], which concluded that comfort and perceived productivity are greater in buildings where occupants have control over ambient conditions and where the buildings employ both natural ventilation and air conditioning. Other studies mentioned had drawn similar conclusions. Menzies et al. [7] concluded that productivity was 11% higher (compared to a control group) for workers who were given control over the amount and direction of air flow at their workstations. Brager and de Dear [8] reported a link between personal control of environmental conditions, especially temperature and ventilation, and work performance.

However, Heerwagen [2] also notes a study by Preller et al. [9] that indicates absenteeism associated with Sick Building Syndrome (SBS) could be 34% lower if employees are given control over temperature and ventilation. This suggests a link between green buildings and productivity that is mediated by air quality and SBS rather than comfort.

Thus, with regard to the link between green buildings and indoor environmental quality (i.e., comfort) it can only be said that the available evidence is weak and that, if there is a link, it can most likely be attributed to personal control of ambient conditions. It now needs to be established whether there is a reason to believe that comfort is linked to satisfaction.

In their review of environmental psychology, Sundstrom et al. [10] outline some of the theories that have guided research on transactions between people and physical environments, including workplaces. Among these theories were the arousal, environmental load, stress and adaptation, privacy regulation, transactional approach, and ecological psychology and behaviour setting theories. The *arousal hypothesis* predicts optimum satisfaction and performance under conditions of moderate arousal. This suggests that temperature, sound, and lighting could influence satisfaction and performance via psychosocial arousal. The *overload hypothesis* assumes that humans have a finite capacity for processing stimuli and information and predicts that we cope with an overload, a noise overload for example, by selectively attending to incoming information and ignoring low-priority inputs. Research on environmental *stress and adaptation* has identified associations between extremes of temperature and sound with physiological and psychological stress (e.g., chronic illness and psychological impairment) and with coping and adaptive behaviours that reduce stress or its impact. Sundstrom et al. note that empirical findings are generally consistent with these hypotheses.

Vilnai-Yavetz et al. [11] suggest that office designers should recognise three separate dimensions: instrumentality, aesthetics, and symbolism. Instrumentality concerns the degree with which physical attributes of the office support the desired activities. Aesthetics refers to the beauty of the office, and the authors note a study that found "beautiful" rooms (as opposed to "ugly" rooms) have significantly different effects on people's short- and long-term perceptions and emotions. The third dimension, symbolism, refers to associations elicited by the space. These authors found a statistically significant association between two of these dimensions, instrumentality and aesthetics, and job satisfaction and performance.