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DO ‘GREEN’ BUILDINGS’ IEQ IMPROVE PRODUCTIVITY?

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Abstract. In this paper we investigate the measurement of productivity in green office buildings. This is as a response to the notion that ‘green’ buildings can achieve greater productivity than buildings that are not accredited as ‘green’. Most of the research in this field has employed self-appraisal to produce an indication that the design of a ‘green’ building can improve the productivity of its occupants. These studies concentrate on proving the importance of IEQ factors on productivity of occupants. This paper tests the reliability of self-appraisal in proving this causal relationship. A developed questionnaire which tests the importance of IEQ factor along with other factors was designed and issued alongside an internationally recognised questionnaire to occupants of a green building in New Zealand. The findings showed that other factors such as poor equipment and loss of sleep were rated to be more important than IEQ factors to productivity. This paper concludes that questionnaires that focus on IEQ not only prompt ideas but also heighten the awareness of a respondent to issues that may be of little or no consequence to productivity.

Keywords. Green buildings; IEQ criteria; productivity; occupants.

1. Introduction

Improving occupant productivity at a minimal cost has always been a welcome ideology in the business world. As such, the thought of a possible increase in productivity of workers as a result of renting a certified green building or even working in one has been a major driver in advocating for green architecture for the last decade. For instance, Kats et al., (2003) suggests that if green design measures can increase productivity by 1%, this would, over time, have a fiscal impact roughly equal to reducing property

costs by 10%. This evidence and more; seem to state the apparent relationship between an office Indoor Environment Quality (IEQ) and the occupant's productivity. Deductively, the message preached is that as a result of an adherence to indoor environmental quality (IEQ) criteria of green rating tools and subsequent certification of the said building by the Green Building Council, increased productivity is an almost certain benefit.

With this apparent increased productivity, many 'green' buildings are marketed as spaces wherein organisations can achieve greater productivity. For instance, a study by Jones Lang LaSalle and CoreNet Global in 2010 showed that 48% of Corporate Real Estate (CRE) executives would pay up to 10% more rent to occupy a sustainable (green) building (Jones Lang LaSalle, 2011). Organisations that occupy these 'green' buildings have also testified to this benefit by publishing survey results that show increase in worker productivity as a means of branding. For example, a report by the New Zealand Green Building Council noted a 9% increase in staff productivity from a post occupancy study carried out on a certified green building (NZGBC, 2013). As noted by Charles et al, (2004), 'green' buildings are often marketed with the expectation that there will be improved organisational productivity due to an improved indoor environment, a link which appears to be supported by research.

Numerous studies (Baird & Thompson, 2012; Baird et al., 2012; etc.) claim to show that the IEQ of 'green' buildings do in fact improve the productivity of workers. Equally, there are recent studies that tend to make contradicting suggestions that cannot be swept under the carpet (Kolarik et al., 2009; Haynes, 2008 etc.). For instance, a report by Building Quality of Life (2009) noted that so-called 'green buildings' introduce unwanted levels of complication that baffle and overwhelm employees. They are of the opinion that the science of 'efficient design' to help make our buildings greener has also often failed occupants and not taken their true needs into account. McCunn & Gifford (2012) observed that green design in office buildings does not have a positive effect on employee engagement or on environmental attitudes and behaviour.

Most of these studies have employed self-appraisal as a method of measurement of measurement this supposed relationship (Onyeizu, 2013). Self-assessed productivity entails the respondent to make a judgement on self-productivity based on one's experience. While this method is preferred due to its ability to be used across a wide sample population, the view that people are the best measuring instruments for building evaluation (Leaman and Bordass, 2005) and its success in providing indications on occupant comfort and satisfaction, its ability to measure productivity is a record that needs to be straightened. Measuring how productive a worker is in day to day activi-

ties for a normal working period remains a subject of debate (CABE, 2004; Lee & Brand, 2010); and is mainly aggravated in the case of employees whose activity products cannot be measured in a conventional manner represented in numbers/values such as customer satisfaction, knowledge or insight etc. The aim of this paper is to put to frame the use of self-appraisals in proving the relationship between environmental factors of 'green' buildings and productivity of occupants.

It is important to state herein that the purpose of this research is not to invalidate the importance of self-appraisal as a diagnostic measure in building evaluation. It is understood that this variable used in building evaluation studies such as BUS Occupant survey, NABERAS etc. is intended as just a means to the broader end of building assessment. However, the interpretation of building evaluation results from self-appraised productivity to prove a direct relationship between IEQ and productivity is the bone of contention and calls for a revisit of this method.

Results from self-appraisals that have shown increase in productivity as a function of the IEQ in green certified buildings provide an avenue for organisations and rating systems to portray green rating tools as 'productivity improvement pills'. If IEQ evaluation is attempted on the basis of actual productivity data and not perceived productivity; or in relation to all other factors that are in play in a workplace, there might be no significant relationship as purported. Since, actual productivity data in a workplace is almost impossible data to calibrate (Leaman and Bordass, 2000); this research is limited to the significance of IEQ in relation to other factors in the workplace.

2. Review of literature

There have been many attempts in research to put a lasting statement on the relationship between IEQ and occupant productivity especially in green commercial settings. While some tried to show that this relationship exists between individual factors such as lighting and temperature etc. and productivity, others have explored IEQ as a whole. For example, Fisk (2000) carried out a review of past literature showing a direct relationship between IEQ and human performance. Baird's (2010) analysis of 30 sustainable buildings across the globe suggests a significant relationship between overall satisfaction with IEQ in green certified workspaces and productivity of occupants.

Whereas these studies (Lenoir et al., 2012; Tanabe et al, 2013; etc.) have shown a relationship between IEQ and productivity, there is growing findings which strongly indicates otherwise (Meijer et al., 2009; Hedge and Gaygen, 2010 etc.). It is necessary to acknowledge the consensus of a rela-

relationship between extreme IEQ and productivity –of which comfort acts as the mediating factor between the two variables. For example, it cannot be argued that at very low lighting, it is impossible to see let alone read. The same goes for extreme thermal conditions. The question remains at what point this relationship cease to exist. The adaptive IEQ (de Dear & Brager, 1998) and Optimal IEQ (Fanger, 1970) are two major models that attempt to provide an answer to this. While these models function based on the relationship between IEQ and comfort, the ability of this relationship to induce greater productivity is yet to be proved. As note by Adbou et al (2006), there is no evidence that maximum comfort leads to maximum productivity.

Clements-Croome (2000) suggests a wider range of productivity indicators, such as health and well-being, interruptions to work and overtime but still excludes factors outside the workplace (e.g. loss of sleep, personal and work relationships). What is lacking in the indicators for productivity is some idea of the magnitude of these factors. For example, is a good breakfast more important than a 10% increase in daylight? Or does a pay raise or work promotion have more influence on productivity than PMV levels of -0.5 and +0.5? While it may be argued that these factors are outside the control of building designers, the relative magnitude of importance may reduce the validity of self-appraisal that focuses on IEQ. These factors are not characteristics of the architectural principles of ‘green’ certified buildings and are not given adequate attention by research as important determinants of productivity. As such, it is necessary to evaluate the significance of IEQ over other factors to productivity. Very few studies have indicated that IEQ is not as important over other factors. However, there is no empirical evidence available to prove this.

Worker productivity in green buildings has been extensively measured using self-appraisals such as questionnaires. As such, it is assumed that the significance of IEQ to productivity over other factors will be obtained through the same method. To test this, a questionnaire was designed (Onyeizu, 2012) that asked office workers to rank a wide range of factors considered to be significant to productivity. The importance of this survey is not only to show that there are other factors that are often more important than IEQ, but that self-appraisal questionnaires, which attempt to relate productivity to IEQ are in danger of prompting responses and producing biased responses on environmental issues.

3. Method

The questionnaire asked a single simple question “How much do these factors affect your productivity in your workspace?” The factors investigated were selected from a pilot study wherein workers were asked to name factors that have the potential of influencing their productivity. Thirty three (35) most occurs factors were selected and tested to identify their level of importance. For convenience, these factors were grouped into five main groups namely:

- IEQ factors: These are environmental factors that deal with the building physical characteristics based on architectural principles. They are usually specified by building standards and codes such as Green Building rating tools etc. These factors emanate from architectural elements such as Lighting (artificial and natural lighting), Temperature (Air conditioning or natural ventilation) and Acoustics. They include Daylight, Glare, Too hot/too cold, Artificial lighting, Too noisy/too quiet, View and Air quality.

- Social factors: these comprise of factors that deal with the relationship between the worker and people within and outside the workplace that have the potential of influence productivity. They include: relationship at work; relationship outside work, distraction/disturbance.

- Personal factors: do not have direct link with the buildings but directly affect the occupants. They are unique to each occupant and the occupants bring these factors along as they come to work each day. They include: Injury, Loss of sleep, Life experiences, Other financial stress, Medication effects, Health/wellbeing, Transport to Work.

- Organisational factors: are factors that the organization or management has power over. They include policies and regulations put in place in the organization to ensure proper management of workers. They include: Job security, Access to health care, Workload, Refreshments at work and Poor management.

- Convenience factors: are physical factors that deal with an occupant's comfort in a workplace as a result of the facilities and amenities made available to the occupant. They include: Overcrowding, Inadequate equipment, Uncomfortable furniture, Position relative to equipment, Cleanliness, Office décor, Personal storage, Privacy, Positive relative to colleagues, Poor Equipment and Furniture arrangement.

The questionnaire was designed such that these factors are arranged in an unprecedented manner to avoid any form of bias or misleading. The factors were then arranged in a set of 5 with the factors spread evenly across the sets. This was done to give each factor equal opportunity at being identified by the respondents as important and to avoid any possible bias.

The convenience sample method was adopted for this survey. This enabled the researcher to access as many respondents as possible so far as they work in the sample building. The questionnaire was distributed to office workers in a 'green' building. The survey was carried out in the winter season (July- September) in Auckland, New Zealand. The average temperature during the time of survey was recorded at 12^oC with substantial amount of rainfall (0.5mm). The survey was carried out immediately after a standard, internationally recognised, self-assessment productivity questionnaire had been carried out. This meant it was administered under the same protocol but it also meant that the participants had already been alerted to the importance of IEQ factors which may have influence on their responses to overvalue these factors. The questionnaire was given out by 10am on the survey day and the collection process was carried out the same day at 3pm.

4. Findings

The questionnaire was given to 60 people of whom 49 responded. Data collected were processed with SPSS to calculate the valid percentage of frequencies for each factor. In assessing an overall value of importance, the responses were weighted such that 'indifference' was multiplied by a factor of 0, 'slightly important', 1 and 'important' by a factor of 2. The factors are then ranked in the order of importance.

The results (Figure 1) show that "Poor Equipment" and "Loss of sleep" were perceived as the most effectual factor by the respondents with rank score of 149. This is closely followed by "Health/wellbeing" (138.8) and "Workload" (136.7). "Poor management" came in as the 4th most effectual factor (131.9) and "undervalued" took the 5th rank with a rank score of 126.5. Too hot/too cold is the first IEQ factor to be considered important to occupant productivity by the respondents with a rank score of 124.5 taking the 6th position in the ranking. This is followed by "Relationship at work" (116.7) and "Inadequate equipment" (116.4) occupying the 7th and 8th positions. The next IEQ factor that was identified by the respondents is Air quality (116.3) taking up the 9th position. The rest of IEQ factors came in as 14th - "Glare" (95.9); 16th - "Too noisy/ too quiet" (91.8); 19th - "Daylighting" (85.8) and 29th - "Artificial lighting" (53.2).

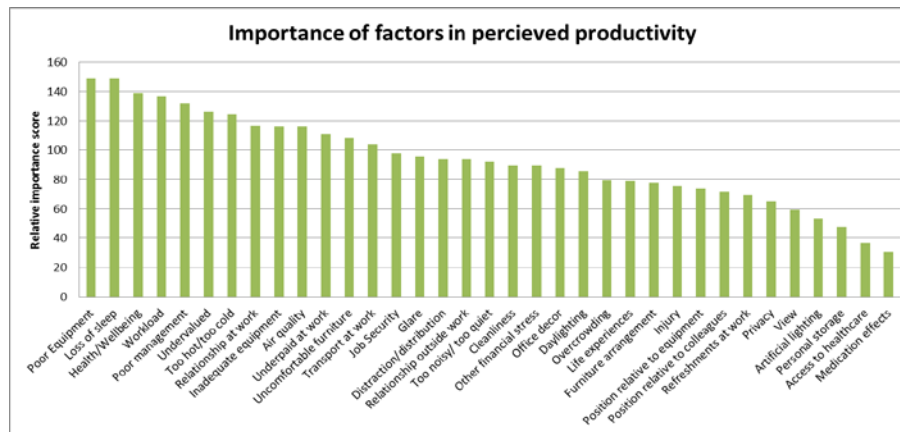


Figure 1: Importance of factors to perceived productivity

Considering the first 10 factors important to productivity, Temperature (too hot/too cold) and Air quality were the only two IEQ factors considered important by the respondents. The time of survey and type of building could explain why these factors were identified as important. This survey was carried out in the winter period of the year and the building is naturally ventilated. As such, there is no artificial means for heating and cooling. This might not be the case during the summer season. An interesting finding is the perception on the importance of lighting and view to productivity. All the aspects of lighting tested received low relative importance value (daylight, glare and artificial light) “Views” (28th) by the respondents. This is intriguing since the building’s façade is glazed on the south and north views to give occupants the privilege of “View”. This shows that when compared with other factors, these IEQ factors are not that important especially if attention has not been drawn to them.

On the other hand, the importance of other factors was highlighted in this survey. “Poor equipment” and “loss of sleep” were perceived as the most important factors (1st) to productivity. Followed by the health and wellbeing of the worker, workload, poor management, and undervalued making up the 5 most important factors to productivity in the workplace. These factors represent convenience, personal and organisational factors. Other factors that were regarded as important were relationship at work, inadequate equipment and being underpaid at work making up 10 most important factors to productivity.

Generally, this result shows that the respondents valued other factors over IEQ factors in their workspace. These factors are not characteristics of a building and do not relate to the ‘Green’ criteria of rating tools. As such, they are not measured in the evaluation of ‘Green’ buildings.

5. Discussion

The results showed that other factors significantly outweighed IEQ factors in the self-assessed productivity evaluation carried out with the top five responses all being convenience, personal and organisational factors. The outcome of this survey is supported by Adbou et al., (2006). The authors reviewed available literature on qualitative relations between IEQ and worker productivity. They noted that other factors such as labour-management relations, interaction between workers etc. are far more important to worker productivity. The relevance of the results of this survey to IEQ claim on productivity is that firstly, questionnaires that focus on IEQ not only prompt ideas but also heighten the awareness of a participant to issues that may be of little or no consequence to productivity. Secondly, responses to the environmental questions in self-assessment questionnaires may well be influenced by other factors. For example, there is a direct correlation between sleep deprivation and performance (Alhola & Päävi, 2007). A response with a low scoring IEQ may be more representative of the individual's state of mind than of the state of the office environment. Thirdly, perceived productivity is not and cannot be equated to actual productivity as there is no context-free basis for perception; it is often influenced by different factors that create bias in response. As such, published outputs of self-assessed productivity questionnaires, which focus on IEQ factors, put undue emphasis on the accuracy of their results. Perceived productivity are being wrongly used to brand 'green' certified office buildings as spaces that provide the appropriate IEQ for greater worker productivity. The tenuous link between perceived and actual productivity combined with only a single question on productivity in the questionnaires and no definition of 'productivity' makes this method of measurement unreliable.

This survey is of limited value in its detail since it would need to be carried out in different building types and over different seasons in order to be more representative. But then, the findings of this result suggest other avenues through which occupant productivity can be enhanced. It also acts as a wakeup call for green rating systems to seek for better reasons to advocate for green architecture and sustainable construction. This survey also indicates the need to include other factors that are outside the boundaries of IEQ in the evaluation of worker productivity.

6. Conclusion

This paper has focussed on the indoor environmental quality (IEQ) of 'green' buildings that can be achieved by architecture. The concern of this paper is whether or not the method by which worker productivity in 'green'

certified buildings is measured is sufficient to prove that green accreditation increases productivity. These claims are based on results that appear to be extremely precise and can measure the percentage increase in productivity to two decimal places. This paper has shown that when compared with other factors, IEQ is of less significance to productivity. Other factors such as sleep, poor equipment etc. are regarded to be more important IEQ factors to worker productivity. It also shows that the manner at which questions are asked often prompt bias and awareness to factors that might not be of importance to a respondent. The results of the standard, internationally recognised, self-assessment productivity questionnaire administered to the same respondents show conflicting ratings to effects on productivity. This is presented in another paper by the authors.

While green certification is a means to the good end of environmental sustainability, the claim on greater worker productivity as a product is unsubstantiated and cannot be adequately measured. As such, other avenues to encourage stakeholders interest in green architecture should be explored such as makes a strong statement that The focus of this paper has been on 'green' certified buildings, however, the implications of this study can be related to older buildings that are been renovated to 'green' standards as this is a rapidly growing area in the industry.

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